Instructional Materials in Weather & Climate

Below are the CLN "Theme Pages" which focus on specific topics within Weather and Climate. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality Theme Page
- Clouds Theme Page
- El NiñoTheme Page
- Blizzards & SnowTheme Page
- Floods Theme Page
- Global Warming/Climate Change Theme Page
- Hurricanes Theme Page
- LightningTheme Page
- Ozone Depletion Theme Page
- TornadoesTheme Page
- Water Quality Theme Page

General Weather and Climate Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Weather and Climate. Please read our disclaimer.

- AskERIC Lesson Plans - Science: Earth Science

  There are a number of lessons on weather within this general earth science collection.

- Bizarre Stuff You Can Make In Your Kitchen

  This site is an ever growing warehouse of the kinds of projects some of the more demented of us tried as young people, collecting in one place many of the classic, simple science projects that have become part of the collective lore of amateur science. It is a sort of warped semi-scientific cookbook of tricks, gimmicks, and pointless experimentation, concoctions, and devices, using, for the most part, things found around the house. These are the classics. Strange goo, radios made from rusty razor blades, crystal gardens... amateur mad scientist stuff. If you happen to learn something in the process, consider yourself a better person for it.

- Earth and Space Science

  About 10 brief lesson plans in weather for elementary level students from CanTeach.

- Especially Elementary

  Three lessons on weather for elementary students.

- Forecasting

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on weather forecasting, student activity assignments, and links to other sites where students can collect the data to answer the questions.

- Gathering Weather Information

  A six day teaching unit in which students gather weather data from the internet and use them to predict weather patterns.

- How the Weatherworks: Activities, Experiments and Investigations

  Four activities that can be used to study the sky and clouds.

- National Geographic.com

  Use the keyword search engine on this home page of the National Geographic.com web site to retrieve weather/climate resources from their database (keyword = "climate" will produce more hits, but try keyword = "weather" as well). Caution: not all of the lesson plans may be what you're looking for and you'll get more than just lesson plans with the keyword search.

- [The] Sky's the Limit

  Each month, IBM provides a new set of Internet activities focused around a specific theme for a targeted range of grade levels. This link is to a unit in which grade 5-9 students use the Internet to research clouds, rainbows, and other weather related phenomena found in the sky.

- Understanding World Climates

  A two week teaching unit for grade 5 students who start by learning the basic reference points and grids used on the earth and end with a beginning knowledge of world climates. Student activities include mapping reference points and climate zones, constructing climographs, solving climograph locations' mysteries, constructing rainfall isolines, and writing and illustrating mini notebooks of the controls of climate.

- Weather

  This page within Houghton Mifflin's Education Place Web Site has four extension activities for primary students: Tracking Local Weather, Measuring Rainfall, Wind Direction, and Wind Observation.

- [The] Weather Dude

  A weather page especially for kids, parents and teachers from Seattle's KSTW-TV. There are links to explanations of weather terminology, links to teacher/parent resource materials on weather and other sciences, and links to resource materials where kids can learn more about weather and other sciences.

- WeatherEye

- Weather/Meteoroloy

  The Nebraska Earth Science Education Network (NESEN) has collected about 30 lesson plans , organized by age groups, in meteorology from NESEN teachers.

- Weather: The Final Front

  Here's a meta-list of links to pages of weather activities/lessons designed for K-12 students and teachers by a Northern Ontario Consortium. Their categories of weather lessons include: air, atmosphere, climate, interpreting the weather, precipitation, water cycle, and weather in general.

- Weather Here and There

  A six lesson integrated weather unit incorporating Internet interaction and collaborative problem solving for students in Grades 4-6 (Math, Science, Geography, and Language arts).

- Weather or Not: Here I Come

  The New Jersey Networking Infrastructure in Education Project provides this lesson plan in which students collect data for weather and marine reports.

- [The] Weather Unit

  This interdisciplinary Weather Unit, intended for students in Grades 2-4, has lessons and activities that can be implemented in various subjects (math, science, reading & writing, social studies, geography, art, music, drama, physical education).

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Note : The sites listed above all have lesson plans/activities for the Weather teacher. For other resources in this subject area (e.g., instructional materials in General Science, Life Science, or Physical Science), or for curricular content and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Air Quality Theme Page

CLN Theme Pages

Below are the CLN "Theme Pages" that support the study of Air Quality. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) that will help teachers provide instruction in this theme.

- Global Warming/Climate Change
- Ozone Depletion

Air Quality Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Air Quality. Please read our disclaimer.

- Acid Rain

  In this interdisciplinary Web research project, junior high students use the Web to research information in the field of a chosen specialist, compile and analyse the data, meet with each other, and then write a report on their findings. The basic questions that they address are: What is acid rain? How does it affect the environment (and us)? Where does it come from?How can it be prevented or minimized? They may choose to be a specialist in chemistry, economics, history, environment, health, or politics/government. Each specialist is given a set of Web links to begin the research.

- Acid Rain Program

  A comprehensive site from the U.S. Environmental Protection Agency with information about acid rain. The following list of links to their site are particularly relevant to students.

  - Acid Rain: A Student's Sourcebook (A unit on acid rain that has background information, descriptions of the causes and effects of acid rain, solutions about what can be done, and experiments with activities.)
  - Effects of Acid Rain This page provide more information on how acid rain effects our environment.

- Air Junk

  Here's an activity for children to make airborne junk collectors and collect air samples. Some background information is also provided.

- Air Pollution

A site established for European schools and designed for younger students, it explores the following seven areas of concern for air pollution: Acid Rain, Domestic Smoke, Smog, The Greenhouse Effect, Particulates, Radionuclides, and Ozone Layer Depletion. Included with each page is a link to a glossary for words used while discussing air pollution.

- Air Quality

Greater Vancouver Regional District publishes a large collection of information concerning the air quality for Fraser Valley and Vancouver area. The links are identified as particularly important air quality concerns and their principles can be applied to areas in the world.

- Air Quality Lesson Plans and Data

The Texas Natural Resource Conservation Commission provides a number of lessons and activities for educators who wish to teach K-12 students about air quality. Lesson plans are provided on such topics as acid rain, air pressure, ozone, plants, oxygen, and pollution control.

- Air Quality Research Branch (Clean Air)

As part of Environment Canada, the menu on this page will link you to air quality information as it is impacted by the following air pollution concerns: acidifying emissions, persistent organic pollutants (POPs), hazardous air pollutants, smog, stratospheric ozone depletion, and climate change. In addition, there is a link with a focus on the Arctic because scientist are finding that the Arctic is the ultimate resting place for many air pollutants.

- Automobiles and Light Trucks

The U.S. Environmental Protection Agency publishes information about the impact of automobiles and air quality that includes carbon monoxide, ozone, emissions and tips on how you can help to reduce air pollution with your car.

- Health and Air Quality - Let's Talk About Air

Educational materials on air quality, indoor air quality, and pollution.

- Educational Resources for Students and Teachers

Lesson plans, activities, and fact sheets on air quality from the Louisiana Department of Environmental Quality.

- Environmental Priority - Clean Air

A page by Environment Canada that explains what causes air pollution, why we should be concerned and what is being done to protect our air.

- It's Your Health

The depletion of our ozone layer has a serious impact on future generations from the dangers of being exposed to the sun's ultraviolet rays (UV rays). The information on this page describes how UV rays can cause sunburn, premature skin aging, cataracts and skin cancer, and even weaken the immune system.

- Indoor Air Quality (IAQ)

Studies have indicated that indoor air pollution can have significant effects on human health.

This site investigates a number of the factors causing us to experiences greater exposure to indoor air pollution than in past decades. Many of these factors have to do with construction techniques and materials used in modern buildings. This site presents information on three environments that affect us: l arge buildings, homes and residences, and schools.

- [The] Kyoto Protocol: Challenges and Opportunities

  Documents in this site explain the historic agreement from December 1997 Kyoto Protocol that commits the developed countries to reduce their greenhouse gas emissions to acceptable levels. It identifies a number of issues raised by different countries and the reduction conditions Canada agreed to.

- Microbiological Contamination of Residential Indoor Air

  Here's information about how humid or damp conditions in the home promote the growth of bacteria, mold and dust mites. Also you'll find how these organisms can contribute to poor indoor air quality and how they can cause health problems.

- Project A.I.R.E.

  A.I.R.E. (Air Information Resources for Educators) was designed as a source of resources for K-12 teachers on air pollution issues. It includes warm-up exercises, lessons, and additional reading information - all saved in PDF format.

- Smile Program Biology Index

  Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has a few lessons on air quality in their section on Environmental Studies and Ecology. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- Smog and Your Health

  You can read about how smog has become the term given to the chemical "soup" that is often visible as a brownish yellow haze over urban areas. Formed from motor vehicle and industrial pollution, smog is potentially hazardous to human health by seriously affecting the respiratory system.

- Urban Smog

  Environment Canada publishes information about what smog is, how to know you are in it, the effect on your health, and what can be done about it. The following link is designed with the younger student in mind.

  - Smog: Let's Clear the Air (A page with similar information as the site, but written for students.)

- Unified Air Toxics Website: Basic Facts

  The basic facts on this page include: What are Toxic Air Pollutants? What are the Effects of Toxic Air Pollutants? Which Pollutants are Considered Toxic? and How are Toxic Pollutants Released into the Atmosphere? In addition, there are links to further information on health risks associated with air pollution.

- What's Riding the Wind in Your Community?

  Yet another resource from the US Environmental Protection Agency. This is a one week teaching unit for students in Grades 5-8 in which they collect air samples and analyze them.

- Workplace Air Quality

  Information defining what "Indoor Air Pollution" is and the effects on our health from many of the pollutants that could be in the air. Some of the pollutants listed (along with their effects) include: tobacco smoke, formaldehyde, volatile organic compounds, microorganisms, asbestos, carbon monoxide and more. In addition, there is a checklist to test your environment and what you can do improve your indoor air quality.

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Note: The sites listed above will serve as a source of curricular content in the study of Air Quality. For other resources in Social Studies (Environment) (e.g., curricular content in Biomes, Endangered Species, or Hazardous Waste Disposal), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Clouds Theme Page

This "Theme Page" has links to two types of resources related to the study of clouds. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- ## All About Clouds

  USA Today has a series of hyper-linked articles on clouds. Topics covered include: types of clouds, interrelationships between stability and clouds, and how clouds influence weather.

- ## AskERIC Lesson Plans: Meteorology

  The above link is to AskEric's Meteorology page where you'll find plenty of lessons about the weather if you wish to browse/search their site yourself. Or, use the links below to go directly to some lesson plans specifically about on clouds.

  - Cloud Types A lesson plan for Grade 5 students. Students will be able to identigy and describe four different cloud types (cirrus, stratus, cumulonimbus, and cumulus).
  - Clouds A multidisciplinary lesson for grdes 4-6 that not only teaches them about clouds but can encourage abstract thinking, writing and painting.
  - Weather Forecasting Grade 6-8 students learn abaout basic cloud formations in this unit on forecasting weather.

- ## [The] Cloud Case

  WeatherEye, a public service of KGAN presents this interactive lesson for grades 5 to 8 students (teacher's guide).

- ## Cloud Formation

  A lab experiment through which students can determine how clouds are formed.

- ## Cloud Gallery

  This site provides different photographs of clouds that students may download, use, and/or adapt as they wish.

- ## Clouds and Precipitation

  From the University of Illinois: "The purpose of this module is to introduce a number of cloud classifications, different types of precipitation, and the mechanisms responsible for producing them."

- ## Clouds: One Key to Foretelling the Weather

  This tutorial from Environment Canada gives brief explanations on how various types of clouds are formed as well as pictures of sixteen types.

- How the Weatherworks: Activities, Experiments and Investigations

  Activities that can be used to study the shape and color of clouds.

- PSC Meteorology Program Cloud Boutique

  A general cloud reference source with detailed pictures.

- [A] Review of Theoretical and Observational Studies in Cloud and Precipitation Physics: 1991-1994

  The content at this site is presented at a somewhat advanced level but it should be appropriate for high school students. Topics include: various types of clouds; electrification of clouds; clouds as components in the global climate system ; possible influence of cloud condensation on climate; acid rain and cloud chemistry, and more.

- Tips for Painting Clouds

  Just what a teacher needs for a multi-disciplinary unit on clouds.

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Note: The sites listed above will serve as a source of curricular content in Clouds. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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El Niño Theme Page

This "Theme Page" has links to two types of information related to the study of El Niño. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- El Niño

  An instructional module from the University of Illinois which introduces El Niño, describes the conditions responsible for its occurrence, and outlines the impact it has on the rest of the world (e.g., weather, economy). Also provided are data on non-El Niño years, sea-surface temperature plots, detection and prediction information.

- El Nino: Canadian Effects

  Learn about the effect of El Nina on all of Canada or specific Canadian regions.

- [The] El Niño

  The Institute of Ocean Sciences (IOS) of Fisheries and Oceans Canada provides this British Columbia resource. Included is information on: An Historical Sketch; What is the effect of El Niño on B.C. coastal waters? Brief notes on the biological impacts; How does El Niño work? How does this affect higher latitudes? El Niño forecasting - how are we doing? The Current Situation.

- El Niño and La Nina

  "USA Today" sponsors this site which provides not only general background information articles but also links to current news stories about El Niño's impact around the world.

- El Nino or El No-no

  In this Web Quest, students learn more about El Nino and La Nina Cycles by collecting and analyzing data and sharing their findings in a speculation paper.

- El Niño Loss Reduction Center

  The US Federal Emergency Management Agency provides wide ranging information on the potential disruptive effects of El Niño.

- El Niño Versus Non-El Niño Years

  A lesson plan for students in grades 9-12 in which they compare and contrast El Niño data. Note: the actual data are not provided as part of this lesson plan but they should be available from other sites on this web page.

- El Niño:Understanding and Predicting via Our Current Technology

  An on-line course for students in grades 9-12. In addition to basic information about El Niño, there are links to research information and other El Niño sites, access to earth science data, and connections to Earth scientists and Earth science teachers.

- El Niño/Southern Oscillation (ENSO) Information

The National Oceanic and Atmospheric Administration (NOAA) provides: What happens during an "El Niño"? A 3-D animation of the tropical Pacific ocean during a simulated ENSO cycle; What are the effects of ENSO on climate? What is the current state of El Niño? Some differences between recent El Niño events; What is the state of the current climate? What are the forecasts for El Niño? Resources for teachers.

- Exploring the Environment: El Nino

This module is part of "Exploring the Environment"[a] (ETE) from NASA's Classroom of the Future[a]. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the El Nino module, click on "Modules and Activities" and then "El Nino".

- National Oceanic and Atmospheric Administration (NOAA)

This US government site has answers to frequently asked questions, information on impacts of El Niño, forecasts, and access to related data.

- Science with Noaa Research: El Nino

An instructional module from the University of Illinois which introduces El Niño, describes the conditions responsible for its occurrence, and outlines the impact it has on the rest of the world (e.g., weather, economy). Also provided are data on non-El Niño years, sea-surface temperature plots, detection and prediction information.

- Tracking El Nino

This Nova Online Web Site explores different aspects of El Nino including an Anatomy of El Nino, Chasing El Nino and and El Nino's Reach. You can also read a correspondent's dispatches on El Nino for a PBS/Online Adventure.

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Note: The sites listed above will serve as a source of information about El Niño. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Blizzards and Snow Theme Page

CLN Theme Pages

Below are the CLN "Theme Pages" that supplement the study of blizzards and snow. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans), which will help teachers provide instruction in this theme.

- Antarctic Theme Page
- Arctic Theme Page
- Glaciers Theme Page
- **Natural Disasters**
  - Avalanches Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Blizzard and Snow Resources

Here are a number of links to other Internet resources that contain information and/or other links related to blizzards and snow. Please read our disclaimer.

- Blizzard Attack

  In this interactive lesson, grade 7-12 students make a fictitious journey between two cities during adverse weather conditions, and learn some of the basic skills needed to stay safe during winter storms. A teacher's guide is available.

- Building an Igloo

  Even if you're not interested in actually building an igloo, this site will explain how its construction can keep people warm in severe weather conditions.

- Don't Be Too Flaky

  An activity in which students measure the density of water, ice, and snow.

- ## Ice and Snow

  Dragonfly Magazine has four articles about snow where kids can learn about the Antarctica and making an igloo, learn why ice floats and is slippery, read interesting facts about snow, or make a virtual flake.

- ## In Praise of Snow

  This lengthy article in the Atlantic Monthly is an intellectual study of snow - for high school students only.

- ## All About Snow

  If you want to know why snow is white, or why forecasting snow can be so difficult, this is the site for you. Learn the difference between a blizzard and a squall, or find out what graupel is in theGlossary page. Check the snow Gallery for some historic photos of blizzards and snow from the National Weather Service.

- ## Mad Scientist Network

  Use this search engine to find all the Mad Scientist Network files on "snow", and you'll find over 150 questions about snow that students have asked and had answered. The answers tend to be brief, but the sheer quantity of information available in the files is worthwhile.

- ## **Minnetonka Elementary Science Center**

  - Snow/Water/Ice A lesson plan in which K-1 students learn to identify two properties of snow.
  - Snowman Unit Grade 2-3 lesson plan in which students make a snowman, write a descriptive paragraph about making it, and then perform a variety of mathematical measurements on it.
  - So Much Snow Grade 4-5 students explore how much water results from the melting of two litres of snow.

- ## **National Snow and Ice Data Center**

  - [The] Blizzards of 1996 The site explains what a blizzard is, why they're dangerous, and why there was so much snow in the 1996 blizzards.
  - Have Snow Shovel, Will Travel A web document giving historical descriptions of snow/blizzards in the U.S. - including how the settlers coped, a history of snow removal efforts, famous snowstorms, snowiest cities in the US, and blizzard safety.
  - Questions and Answers about Snow
  - Snow Fact Sheet
  - Snow Glossary

- ## Precipitation: Online Meteorology Guide

  An explanation of the varying atmospheric conditions that produce hail, freezing rain, sleet, and snow.

- ## Snow

Students can learn about the basics of snow, snow art, and how to build a snow castle.

- ## Snow Activities

  There are lots of elementary teaching resources offered by this home schooling family. Included are suggestions for snow-based activities within science, art, literature, and food.

- ## Snowbound

  The Grade 7 Natural Disasters Project provides a brief description of blizzards along with a wind chill chart.

- ## Snow Flake Designs

  - Ben & Jerry's Happy Holiday Paper Snowflakes Instructions for making three paper snow flake designs.
  - How to Make Paper Snowflakes General instructions for making paper snow flakes with different designs.
  - Snowflake Detailed instructions.
  - Snowflake Designer Design your own snowflake using this interactive Shockwave plug-in.
  - Snowflakes Instructions for making five paper snow flake designs.

- ## Snow Flake Imagery

  - Electron Microscopy Unit Snow Images of snow crystals made from a low temperature scanning electron microscope.

- ## Snow School

  Spring Brook Manufacturing, a snowshoe company, offers a collection of lesson plans/units on snow. Be sure to see their selection of lesson plans and ideas for teaching PE in the snow (e.g., Pass the Snowball, Human Sled Pull, Orienteering, Raid the Snow Fort). For outdoor education information on how plants and animals live in snowy conditions, check out the link to the Glacier National Park Environmental Education Guide. There are also a couple of experiments with snow - some of which are their own and some from other sites that are already on this Theme Page.

- ## Snowtastic Snow

  Here's a Web Quest Junior contestant with lots of information about snow. Elementary students can read about the ice age (history), learn about hypothermia (PE&Health), learn more about the science of snow, play games, or engage in a couple of activities.

- ## TrackStar

  TrackStar is an online interface that allows instructors to create lessons for students by sequencing existing instructional content in various Websites within a lesson. Students explore one topic at a particular location within one Website, then move on to the next topic at another Website. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the Websites beyond the designated instructional content are also possible.

This link is to their search page from where a keyword search on "snow" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding Websites, sequencing the tours) will vary widely within the TrackStar collection.

- Winter

  Suggestions for some primary level winter activities that include literature sources, bulletin board ideas, science activities, and crafts.

- Winter Storms

  A unit on winter storms, complete with interactive components: weather maker, and winter storm timeline.

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Note: The sites listed above will serve as a source of curricular content in Blizzards and Snow. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

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Floods Theme Page

Below are the CLN "Theme Pages" which supplement the study of floods. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page
- Water Quality Theme Page

General Floods Resources

Here are a number of links to other Internet resources which contain information and/or other links related to floods. Please read our disclaimer.

- Flood Hazard Management

  The BC Ministry of Water, Land and Air Protection provides various information about flooding in BC including: flood hazard management, floodplain mapping, emergency response (e.g., sandbag dike construction), picture images.

- Dartmouth Flood Observatory

  Dartmouth College in the US uses remote sensing technology as a tool for early detection, mapping, measurement, and analysis of world-wide extreme flood events. In addition to downloadable satellite images, there is a register of international large river flooding for the last several years in their site.

- FEMA for Kids

  The U.S. Federal Emergency Management Agency has developed this site so that young students can learn about various disasters, what to do during and before them, and what causes them. The site also includes activities (games, quizzes, challenges), a library of resources (e.g., pictures), and resources for parents and teachers.

- Flash Flood

Here's an interactive lesson for students in grades 3-10 about flash floods and other types of floods. Topics include identifying different types of floods, preparing for a flood, flood watches and warnings. A teacher's guide is included as are a student assignment and quiz.

- Flood!

This web site is a companion to a Nova program on the flooding of the upper Mississippi flood plain in 1993. Students can read how people dealt with the deluge and learn the benefits of a flood. A teacher's guide is available.

- Floods: How Can Water be Powerful Enought to Move a House?

Newton's Apple, a public television production, provides student activities so that they can better understand floods and their control.

- Floods: What To Do Before and After

Advice from the Canadian Mortgage and Housing Corporation on the precautions one can take before a flood and what one can do afterwards to repair damages.

- Flood Stories From Around the World

Story legends about floods organized by region of the world.

- Just Doing My Job

In this site, grade 6-10 students can learn how satellite images were used to help flood evacuations during a 1993 US flood. In addition to the story, the site contains student activities and a teacher's guide. There is also a link to another NASA site in which students engage in activities to learn more about remote sensing technology.

- Manitoba Flood Information

This is the Government of Manitoba's Flood web site. In addition to announcements about current potential flooding, it has information about the flood of 97 as well. Included are facts and figures of the flood, photographs, personal health and safety guidelines, guidelines for what to do when returning to flooded out residences, and advice on avoiding scams.

- Red River Diary

The virtual diary of a free lance writer and photographer who chronicled the Red River flood of 1997 (North Dakota and Manitoba) while it was happening. Read their observations and view their pictures as they provided web coverage of the flood.

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Note: The sites listed above will serve as a source of curricular content in Floods. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

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Global Warming/Climate Change Theme Page

Below are the CLN "Theme Pages" which support the study of Global Warming/Climate Change. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality
- Ozone Depletion

Global Warming/Climate Change Resources

This "Theme Page" has links to two types of resources related to the study of global warming / climate change. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- Encyclopedia of the Atmospheric Environment

  Published online in 2000, the "Encyclopedia of the Atmospheric Environment" is a clever two-level encyclopedia about climate, global warming, weather, and related topics for grades 9 to 12 students.

- Environmental Change Education/Outreach Program

  The Nebraska Earth Science Education Network (NESEN) has collected over a dozen lesson plans in climate change from NESEN teachers participating in two workshops. Look in the 1997 and 1998 workshop sections for the lesson plans.

- Explorer: Global Warming

  A downloadable lesson plan complete with overhead masters (in pdf format) for students in grades 3-9. "This lesson plan covers the major greenhouse gases, human activities that contribute to the change of the Earth's atmosphere, and why there is a concern about climate changes. Also addressed are strategies for dealing with potential global warming and the major contributors to global warming. The possible effect of a global warming on forests, agriculture, health, wildlife, and the oceans are addressed."

- **[The] Franklin Institute Science Museum**
  - Bringing the Greehouse Effect Down to Earth In this lab activity, high school students compare the amount of Carbon Dioxide in four different sources of gases.

- [The] Greenhouse Effect in a Jar An elementary/junior high experiment that will serve as an introduction to the greenhouse effect. Skills include observing and recording data, use of a control, drawing conclusions from results, and use of a model.

Global Change

This teaching unit from the United States Geological Survey is intended for students in grades 4-6 although some activities can be used with older or younger students. The unit consists of an introduction and many activities. Each activity has background material, an experiment, suggestions for further reading and extensions.

Global Climate Change

Environment Canada provides answers to the questions: "What is climate change?" "What is Canada doing?" "How will climate change affect you?" and "What can you do?" There are other useful resources within or linked to this site - we've provided direct links below.

- Government of Canada: Global Climate Change This site has been designed specifically to inform Canadians about climate change, how it affects our environment, and what the Canadian government is doing about it. In addition to these sections, be sure to check out the Resource Room as well as the Activity Room.
- [A] Primer on Climate Change Indepth information on the issue of climate change, its impacts, and measures we can explore to reduce greenhouse gas emissions.

Global Climate Change Student Guide

The online textbook "Global Climate Change Student Guide" is an authoritative Web resource for upper-grade and college Environmental Science students.

Global Warming: Focus on the Future

There are four sections to this site. In "It is happening" students can get the historical perspective on global warming as well as information on what the issue is. There are also articles describing impacts, discussions of solutions, and games/puzzles for students.

Global Warming Unit

This teaching unit from LETSNet (Learning Exchange for Teachers and Students through the Internet) consists of five lessons designed for middle school and high school students.

Greenhouse Warming: Fact, Hypothesis, or Myth?

A look at the validity of the Greenhouse Warming Theory.

National Environmental Indicator Series - Climate Change

Environmental indicators are selected key statistics, which represent or summarize a significant aspect of the state of the environment, natural resource sustainability, and related human activities. This site provides information about the climate change issues such as: Carbon dioxide intensity, Global atmospheric concentration of green house and more.

National Forum on Climate Change: Proceedings

These proceedings are the records of a series of meetings which brought together a citizens' panel of 25 respected Canadians in a National Forum on Climate Change in 1998. The panel heard a full range of expert opinion and examined all aspects to the topic objectively. The information is arranged in a series of meeting minutes and, as such, access to the reports is somewhat cumbersome.

- ## NASA fact sheets

  NASA Fact Sheets are produced in an effort to educate the general public on the major issues and natural phenomena that scientists will be studying using data provided by the Earth Observing System. These files are in PDF format.

- ## Sierra Club of Canada: Climate Change

  This site provides a view on climate change from the perspective of a Canadian environmental protection group. In addition to basic information on global warming, there are research reports, data summaries, and announcements.

- ## Skepticism Net: Global Warming

  A meta-list of links to resources on the web which dispute or question the claims of global warming.

- ## Still Waiting for Greenhouse

  The introduction to this web site describes itself thusly: "This website demonstrates what many climate scientists know to be exaggerated claims and political propaganda about`Global Warming', based on unscientific (mostly computer model) evidence. The observed evidence indicates that little or no global warming is happening and little should be expected. "

- ## TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "global and warming" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- ## **United Nations Framework Convention on Climate Change**

  - Beginner's Guide to the Convention A description of environmental problems that the world is facing and what we are doing about it through the Convention.
  - Climate Change Information Kit Thirty fact sheets (also in downloadable format) which cover: Understanding of the Climate System; Facing the Consequences; The Climate Change Convention; Limiting Greenhouse Gas Emissions; and Facts and

Figures.

- [The] Convention and the Kyoto Protocol Full text of the protocol along with information on the status of its implementation.
- Country Information Snapshots of action taken by a large number of countries to meet their domestic and international climate change commitments.

Note: The sites listed above will serve as a source of curricular content in Global Warming/Climate Change. For other resources in Social Studies -Environment (e.g., curricular content, lesson plans, and theme pages), click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Hurricanes Theme Page

Below are the CLN "Theme Pages" which supplement the study of hurricanes. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Hurricanes Resources

Here are a number of links to other Internet resources which contain information and/or other links related to hurricanes. Please read our disclaimer.

- 1901-1996 U.S. Landfalling Hurricanes

  A collection of GIF maps that display the locations where and when hurricanes hit the US coastline bordering with the Atlantic Ocean and Gulf of Mexico . Each map is organized by decade and each hurricane is colour coded according to its degree of severity.

- Canadian Hurricane Centre

  Environment Canada, Atlantic Region, monitors all hurricane activity along the Atlantic Seaboard. If hurricane activity appears to threaten Eastern Canada, the Centre will inform the region's residents of potentially damaging weather conditions and provide tracking information and services.

- Counting on the Havoc of Hurricanes

  In this lesson plan, grade 6-12 students use a NY Times article as a starting point to "define and classify all the different ways in which numbers are used in forecasting and coping with the effects of a hurricane. They then conduct research to compare and contrast these numbers as they apply to Hurricane Floyd and other recent hurricanes. Finally, they graph their findings."

- Create an Art Object Depicting a Hurricane

  A practical art lesson plan for any elementary classroom. It can be used with younger students to encourage them to draw representations of hurricanes. This lesson can be easily expanded for older student to include some hurricane research.

- Exploring the Environment: Severe Weather: Hurricanes

This module is part of "Exploring the Environment"[a] (ETE) from NASA's Classroom of the Future[a]. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet-based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the hurricanes module, click on "Modules and Activities" and then "Hurricanes". The challenge students will have is to use the history of Hurricane Andrew (1992) to track, analyze and predict the course of a new hurricane that may threaten North America this school year.

- Handle a Hurricane

In this StormSmart lesson from WICS NewsChannel 20, high school students assume the role of a mayor of a city threatened by an approaching hurricane and needing to make a decision whether to evacuate the city. They read news reports about the storm, memos from staff advising the mayor on whether or not to evacuate, and basic information about hurricanes before announcing their decision.

- [The] Heat is On! Creating Weather Emergency Guides in the Science Classroom

In this lesson plan, grade 6-12 students research severe weather conditions common to their geographic location and create weather emergency guides for extreme weather conditions such as tornadoes, floods, blizzards, thunderstorms and hurricanes. They use a New York Times article as a starting point for their explorations.

- Hurricane!

Use this link to download the .pdf file for a primary level, 10 lesson unit on hurricanes. Students learn report writing skills while studying the weather of the Caribbean islands, hurricanes, and hurricane preparation.

- Hurricane Centre

Current news from a Florida media outlet. In addition, they have information on hurricane tracking, names, and terms. There are extensive sections providing advice to residents on how to prepare for hurricanes. For example, there are hints on: checking your roof, how to find a safe place to hide, building plywood shutters, getting a survival kit organized, what to do with your pet, and much more. A collection of maps is available in different formats for downloading, printing and use on-line to help you track storm and hurricane activities. Also, check out "Hurricanes in History" for brief historical summaries of hurricane events off the US Atlantic coastline, starting with Columbus in 1495.

- Hurricane Disaster Service

The American Red Cross provides extensive information about hurricane preparation and how to stay safe during a hurricane. Information includes on-line resources and downloadable PDF documents.

- Hurricane: Storm Science

  Designed for elementary students, the materials in this site include explanations, diagrams/images, stories, activities, and downloadable materials. Contents cover the following topics: What is a hurricane like? How do hurricanes work? What happens when a storm comes? What paths do hurricanes take? Has anyone else been in a disaster?

- Hurricanes

  Supported by the University of Illinois, this site describes several introductory hurricanes characteristics and issues including: What hurricanes are; How they get their names; What affects their development; and, How to rate their destruction with the Saffir-Simpson Scale. Advanced hurricane information is available after accessing these introductory pages.

- Hurricanes

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on hurricanes, student activity assignments, and links to other external hurricane sites where students can collect the data to answer the questions.

- Hurricanes

  The U.S. Federal Emergency Management Agency sponsors this "FEMA for Kids" site on hurricanes. Students can read information specially developed for them on classification, historical events, naming conventions, origins, disaster scales, and hurricane hunters. The site includes a number of student activities as well.

- Hurricanes Spark a Storm of Classroom Activity

  Education World provides activities and Internet connections to engage students of all ages in a study of hurricanes.

- Hurricane Trailhead

  This is the starting point for a virtual field trip on hurricanes from Tramline. Experts in the subject have selected a number of web sites on hurricanes and arranged them in a sequence to tell a story for students to follow. Students can move from one web stop in the field trip to the next with ample opportunity to explore within the individual web site as they wish. However, since their web browser page has been split into an inner part (showing that stop in the field trip) and an outer part (giving navigational tools to go through the entire field trip), they can always return to their "tram" and go to the next stop. To be effective, teachers would have to ensure that student browsing through the field trip sites was purposeful. Teacher guides can be printed.

- Hurricane Watch

  Internet-based activities related to hurricanes for students across the subjects and across the grades from Education World.

- Images/Movies of Hurricanes and Special Events

  More than 500 satellite photos of hurricanes, tropical storms and typhoons starting from

1968. These photos, collected by National Climatic Data Center, are categorized by year. The collection includes the following types: colour, radar, infrared and MPEG movies.

- ## National Hurricane Center - Tropical Prediction Center

  The Tropical Prediction Center is located in Miami, Florida and works cooperatively with the National Weather Service to track and monitor hurricane and storm activity off the US Atlantic coast. A comprehensive site for information regarding current and past hurricane activity.

- ## Tracking A Hurricane

  A lesson plan designed for students in grade 9-12 who are familiar with trigonometric conversion formulas from rectangular to polar and back again.

- ## TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "hurricanes" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- ## Weather Eye

  We were successful in finding a site of weather instructional materials for teachers. The following links will take you directly to lessons for the grade range listed.

  - Cadet Section 20 weather related lessons for grade 2-8. One of the lessons is for hurricanes, the others could be modified to include hurricane activity.
  - Expert Section Six extensive lessons suitable for Grade 6-12. Most the lessons are designed for role play situations. For example, in the lesson "Handle a Hurricane", students take the role as "Mayor" and must make decisions regarding the town's safety as the hurricane approaches.

- ## [The] Wrath of Hurricane Mitch

  In this lesson plan, grade 6-12 students "investigate how hurricanes and other natural disasters can devastate the elements of the infrastructure of a country, as well as the lives of its people. Students then work in committees, each focused on one element of a country's infrastructure, to analyze the existing infrastructure problems in Honduras caused by Hurricane Mitch, devise possible solutions for these problems, and assess how each aspect of a country's infrastructure is interdependent to the others. Students also determine how lesser developed countries and developed countries differ in times of catastrophe." They use a New York Times article as a starting point for their explorations.

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Note: The sites listed above will serve as a source of curricular content in Hurricanes. For other resources in Weather (e.g., curricular content), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Lightning Theme Page

Below are the CLN "Theme Pages" which support the study of electricity-related concepts such as Lightning. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Electricity (Concepts) Theme Page
- Electronics (Circuitry) Theme Page
- Magnetism Theme Page

General Lightning Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Lightning. Please read our disclaimer.

- Bright Light Fright

  View this section of the Franklin Institute (what would be more appropriate?) for information on the history and science of lightning. They also have a piece on lightning detection.

- Design a Lightening Calculator

  In this activity, students will learn how to predict lightening distances and discover why light travels faster than sound.

- Fire Weather

  The Alberta Ministry of Environmental Protection collects data on lightning strikes within the province and makes them available from this site both cumulatively and daily. They also describe their lightning detection system.

- Frequently Asked Questions about Lightning

  From Kerry Anderson of the Canadian Forest Service in Edmonton

- Human Voltage: What Happens When People and Lightning Converge?

  A readable news article from NASA that describes the incidence and impact of lightning strikes on the human body.

- Kids' Lightning Information and Safety

  Developed by a lightning strike victim, this site offers kids' information on lightning and lightning safety. Sabrina writes, "it really hurts when you are struck by lightning and I want to help other kids to learn more about lightning safety. I want to share what I have learned with you. I think that the more you know, the safer you can be."

- Lightning

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on lightning, student activity assignments, and links to other external lightning sites where students can collect the data to answer the questions.

- Lightning and Atmospheric Electricity Research at the GHCC

  Don't let the name scare you away from this NASA site. For a sound introduction to lightning (history, basics, safety, etc.) check out their "Lightning Primer." Then, to learn more about how NASA's space program is involved, read their section on Space Research and Observations.

- Lightening in a Jar

  Students create lightening in a clear plastic jar with a light bulb.

- [The] Lightning Page

  A very comprehensive site that contains basic explanatory information as well as photo and sound files. A lengthy index lists such sections as survivors, FAQs, myths, strike maps, safety and more. Note this site is actively sponsored by Christian Internet Services (CIS).

- Lightning Photography

  Over 150 photographs by Michael Bath.

- Lightning Photography

  Over 75 photographs of lightning strikes by Dave 'stormguy' Crowley. He also offers photography and safety tips.

- Personal Lightning Safety

  The Lightning Safety Institute offers advice on personal protection in outdoor recreational events, parks, swimming pools, boats, and in general. They also have other useful information.

- Severe Storms: Online Meteorology Guide

  Dangers, types and components of thunderstorms.

- Sparks and Lightning

  An article explaining sparks, lighting and conductive plasma.

- [The] Strike

  This site has pictures of what the owner advertises as the "closest 12 stroke lightning strike ever caught on video" as well as background information on the event. Included are also other pictures from professional stormchasers and links to related sites.

- ## Strike One

  This link is to an archive of over 25 lightning strike pictures taken by Michael Fewings whose goal is to combine artistry with lightning. See also his "current" photographs from this page and his tips on how to "avoid" being struck.

- ## Thunderstorms

  The U.S. Federal Emergency Management Agency sponsors this "FEMA for Kids" site on thunderstorms/lightning. Children can read information specially developed for them on terminology, what lightning is, what if someone is hit by lightning, facts and fiction, photos, things to know, and what one might feel in a disaster.

- ## TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "lightning or thunder or storm" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- ## Weather Eye: Lightning

  Student tutorials, experiments with static electricity, an interactive safety section, and a quiz for grades 5-9.

Note: The sites listed above will serve as a source of information about Lightning. For other resources in Sciences (e.g., curricular content in Earth, Life or Physical sciences, etc), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Ozone Depletion Theme Page

Below are the CLN "Theme Pages" which support the study of Ozone Depletion. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality
- Global Warming/Climate Change
- Reduce, Reuse, Recycle Theme Page

Ozone Depletion Resources

This "Theme Page" has links to resources related to the study of the Ozone Depletion. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- Air Quality Lesson Plans and Data

  The Texas Natural Resource Conservation Commission provides a number of lessons and activities for educators who wish to teach K-12 students about air quality. Lesson plans are provided on such topics as acid rain, air pressure, ozone, plants & oxygen and pollution control.

- [The] Earth Times

  An on-line magazine, Earth Times offers current and past news stories with a focus on the environmental issues, sustainable development concerns, population and current affairs. The Earth Times is the only independent international nonpartisan newspaper focusing on environment and economic development, and such interrelated concerns of the international system as human rights, population, trade, and women's and children's rights. Its mission is primarily to inform and educate audiences about the pressing issues of interdependence in which the environment plays a central role. Present and back issues are available for browsing or searching.

- Exploring the Environment: UV Menace

  This module is part of "Exploring the Environment" (ETE) from NASA's Classroom of the Future. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the ozone module, click on "Modules and Activities" and then "UV Menace."

Fact Sheet: Health and Environmental Effects of Ground-Level Ozone

Ground-Level ozone is the primary ingredient of smog. This page explains in an easy to read format the following topics:

- Why are We Concerned about Ground-Level Ozone?
- Who is Most at Risk from Exposure to Ground-Level Ozone?
- How does Ground-Level Ozone Harm the Environment?
- What Improvement Would Result from EPA's New Standards?
- Background: What is Ground-level Ozone?

(The) Greenhouse Effect

Written for Elementary and Middle school students, to learn about the "The Greenhouse Effect" and "The Ozone Layer".

Ground-Level Ozone

Created for the State of Texas, this page describes the two types of ozone, how it is formed and some of the problems related to each type.

Ozone

Nasa's Observatorium presents an article on ozone for students in grades 9-12 which presents the effects of ozone depletion on the Earth, discusses the formation and destruction of ozone, and summarizes the history and the politics of the Montreal Protocol. There's also a teacher's guide with suggested student activities, but you'll have to read through the article to find it.

The Science of Ozone Depletion

Be sure to check out Effects of Ozone Depletion, Ozone Depletion and Environmental Effects, UV-B Radiation: How to protect yourself.

[The] Ozone Hole Tour

From the University of Cambridge's Centre for Atmospheric Science, this tour begins with an introduction including a history of the issue and proceeds to a description of recent discoveries in the Antartic. The third part of the tour examines the science beyond the issue - what are the ingredients that make ozone loss occur? The final segment summarizes current research.

Stratospheric Ozone

From this comprehensive Environment Canada site, you can learn about ozone depletion, health and environmental impacts, the Canadian Ozone Layer Protection Programs, Canadian data, and international efforts. There's also a special Kid Zone which has these resources especially designed for young students.

- Healthy Living with Sunshine
- Ozone Guarding Our Earth
- [The] Ozone Layer: What's Going On Up There?

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Note: The sites listed above will serve as a source of curricular content in Ozone Depletion. For other resources in Social Studies - Environment (e.g., curricular content), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Tornadoes Theme Page

Below are the CLN "Theme Pages" which supplement the study of tornadoes. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Tornadoes Resources

Here are a number of links to other Internet resources which contain information and/or other links related to tornadoes. Please read our disclaimer.

- (A) Comprehensive Glossary of Weather Terms for Storm Spotters

  This glossary contains weather-related terms that may be either heard or used by severe local storm spotters or spotter groups.

- EarthWatch Weather On Demand

  A graphic intensive site showing satellite and radar weather pictures for North America. At this page, you can choose detailed, current weather images of Canada. The StormWatch button at the top of the page is for the US only.

- [The] Fujita Scale

  "The Fujita Scale (also known as the Fujita-Pearson Scale) is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure." The page also has many links to tornado resources.

- [The] Heat is On! Creating Weather Emergency Guides in the Science Classroom

  In this lesson plan, grade 6-12 students research severe weather conditions common to their geographic location and create weather emergency guides for extreme weather conditions such as tornadoes, floods, blizzards, thunderstorms and hurricanes. They use a New York

Times article as a starting point for their explorations.

- Kansas Tornado Chasers

  The purpose of this site is to educate the public, spotters, and chasers of the subject of tornadoes. The site includes tornado history, photos, videos, forecasts, nowcasts, preparation, and much more. Check out their kidspage and safety links.

- Severe Weather Related Sites

  A meta-list of sites related to severe weather.

- Tornadoes

  Part of Scientific American's site, this page has descriptive information about Supercells, Tornado Chasing, Signature of a Vortex, Spinning Up, and Touchdown.

- Tornadoes

  This instructional unit is part of the "Science With OAR" web site developed by the University of South Alabama. It consists of explanatory sections on tornadoes, student activity assignments, and links to other external tornado sites where students can collect the data to answer the questions.

- Tornadoes: Going Around in Circles

  Sponsored by the National Institute for Science Education, this site provides answers the following questions: What are tornadoes?; Where does a twister get all that energy?; How to protect yourself when a tornado is close?; and How does a twister affect the natural landscape? Get the answers to these questions, then take the "twisted test".

- Tornado in a Bottle

  A lesson plan for grades 3-5 that lets them create a vortex in a bottle.

- Tornado Information Index

  A meta-list of sites from USA Today. It has links to resources on tornado safety, tornado science, tornado research, tornado chasing and more....

- (The) Tornado Project On-line

  A page of resources from a small group who collects, compiles and makes tornado information available. This site specializes in tornado myth, tornado oddities, personal experiences, tornado chasing, tornado safety, and tornadoes from the past.

- Tornado Trailhead

  This is the starting point for a virtual field trip on tornadoes from Tramline. Experts in the subject have selected a number of web sites on tornadoes and arranged them in a sequence to tell a story for students to follow. Students can move from one web stop in the field trip to the next with ample opportunity to explore within the individual web site as they wish. However, since their web browser page has been split into an inner part (showing that stop in the field trip) and an outer part (giving navigational tools to go through the entire field trip), they can always return to their "tram" and go to the next stop. To be effective, teachers would have to ensure that student browsing through the field trip sites was purposeful.

Teacher guides can be printed.

- [The] TORRO Tornado Intensity Scale

  This Scale is used to categorize windspeeds in tornadoes. From the following list, learn about the criteria used to rate the tornado's windspeed: viewing the damage caused, engineering analysis of the damage caused, Doppler radar, photogrammetric analysis, and direct measurement.

- TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "tornadoes" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- Vortex

  Grades 4-10 lesson plan using 2 - 2 litre bottles to create a tornado in a bottle.

- Vortex: Unraveling the Secrets

  The story of an expanding tornado and its resulting consequences are set in a story plot similar to a mystery novel. The authors begin the mystery with a description of some of the events and facts. Then they lead the reader through information that helps them understand and possibly solve why the tornado occurred. There are two versions available, Java enhanced (slow downloading) and low band width.

- (The) Weather Unit

  A weather unit complete with many primary class lesson plans integrated into all subjects areas.

- What is a Tornado?

  A detailed essay describing various characteristics of tornadoes with accompanying photos. Part of its purpose is to dispell misconceptions about tornadoes.

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Note: The sites listed above will serve as a source of curricular content in Tornadoes. For other resources in Weather (e.g., curricular content), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Water Quality Theme Page

Here are a number of links to Internet sites which contain information and/or other links related to the specific theme of water quality. Please read our disclaimer.

- ## [The] Daybook

  From this searchable database of lessons plans, we gathered together the following intermediate grade lesson plans into one location for your convenience:

  - Water Unit: Adhesion: Part 1 of 6 Introduces students to the property of adhesion.
  - Water Unit: Physical Properties: Part 2 of 6 Introduces students to the physical properties of water by having them guide water droplets around a race course outlined on a piece of wax paper.
  - Water Unit: Surface Tension: Part 3 of 6 This unit introduces students to the physical properties of surface tension on water by floating a needle on it.
  - Water Unit: Surface Tension: Part 4 of 6 Students demonstrate surface-tension by dropping pennies into a full glass of water and watching as the water begins to form above the glass.
  - Water Unit: Cohesion: Part 5 of 6 This lesson introduces students to the property of cohesion - the way water likes to stick together. Students are asked to visualize and draw water droplets.
  - Water Unit: The Uses of Water: Part 6 of 6 This final activity involves the students in categorizing the uses of water. They are asked to collect and chart data about the different uses of water in their home.

- ## Eliminating Microorganisms from Water

  An activity, designed by the Chlorine Chemistry Council (CCC), in which students create water samples with microorganisms, examine the sample, and then remove the organisms.

- ## Fundamentals of Physical Geography

  Although this online textbook from Michael Pidwirny, Okanagan University College, is intended for postsecondary students studying introductory physical geography, much of it may be applicable for high school students as well. Contents include over two hundred pages of information, more than three hundred 2-D and animated graphics, an interactive glossary of terms, a study guide, links to other Internet resources, and a search engine. See the Table of Contents to directly access the Hydrology section.

- ## Educating Young People About Water

  The following three links allow you to download PDF files that describe and explain a comprehensive community based water education program.

  - A Guide to Program Planning and Evaluation This first section "walks program planners through the steps in setting up and evaluating a youth water education program- bringing together the key components that can lead to an effective, sustainable program."

- A Guide to Unique Programming Strategies The second part "tells the story of 37 program coordinators from around the country. Discover how they integrate community water education issues and youth development needs into unique program designs."
- A Guide to Goals and Resources This section "provides the program coordinator with 100 water education curricula summaries, environmental education topics and goals, and multimedia resources."

Environment Canada's Freshwater Web Site

Here's a comprehensive Canadian site designed with educators and students in mind. Most content has been written for grade 6-12 students with learning materials available for grade K-12 teachers. From the home page, be sure to check out: The Management of Water (covers topics like water modeling, water pollution, water quality, water use...); The Nature of Water (covers information on ecosystems, ground water, properties of water...); Teacher's Corner (free learning aids ad teaching materials); Water and Culture (articles on water and Canadian identity).

Environmental Priority-Clean Water

A page by Environment Canada that explains what causes water pollution, why we should be concerned, and what is being done to protect our water.

Exploring the Environment: Water Quality

This module is part of "Exploring the Environment"ª (ETE) from NASA's Classroom of the Futureª. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet-based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the water quality module, click on "Modules and Activities" and then "Water Quality".

Floods Theme Page

This CLN theme page provide curricular and instructional resources on the associated topic of floods.

Groundwater in British Columbia

The Ministry of Lands, Parks and Housing of British Columbia maintains a meta-list of links to information and resources relating to groundwater in the Province.

Groundwater Remediation Project

Supported by the National Water Research Institute, this site has information on Canadian groundwater resources including PDF reports on various issues, links to other groundwater sites, and groundwater education.

Hydrologic Cycle

Nasa's Observatorium presents an article explaining the five processes which make up the hydrologic cycle (condensation, precipitation, infiltration, runoff, and evapotranspiration). A quiz and a word search activity are provided as well.

- [The] Incredible Journey

A lesson plan for upper elementary students that uses the roll of a die to simulate the movement of water within the water cycle.

- Lifewater Canada

Extensive information is available regarding a vast array of water pump construction, water collection, water storage, water quality testing and treatment, and effective sanitation. The focus of the information, assembled by a Christian Organization, is to aid Third World countries in improving and developing healthy water sources.

- Liquid Assets

This unit has four lessons on the water cycle, water use, measuring water quality, and water pollution for intermediate/junior high students. Lessons include suggested learning activities that teachers can incorporate with their own ideas.

- Oil, Water, and Chocolate Mousse

The purpose of this Environment Canada site is to provide information about the impact of oil spills. Some topics include: When Oil Spills, Prevention is the Best Cure, Always Be Prepared, What Can I Do To Help? and more.

- Project Wet: Lesson Plans

The Project WET Curriculum and Activity Guide is an interdisciplinary water education program developed for teachers of kindergarten through grade 12. It contains a range of water education concepts and multidisciplinary activities.

- Properties of Water

A lesson plan for K-8 biology teachers on the properties of water. The language level of the content will probably be too high for students to use directly.

- Smile Program Biology Index

Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has a few lessons on water quality in their section on Environmental Studies and Ecology. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- TrackStar

TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

This link is to their search page from where a keyword search on "water" will produce numerous hits. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- U.S. Environmental Protection Agency: Curriculum: Water

  This page contains links to a variety of curriculum resources on water for students as well as links to student activities.

- Utahlink - Teacher Resource Book

  Over 30 science lesson plans from Utah State that are designed for elementary aged students. You can browse through their set of science resources above, or we've made direct links to four below which focus on water and how it interacts in our environment.

  - Activity # 1 - Ground Water Students create a model for the percolation of water through the soil and observe the filtering process achieved as water enters a sample of ground water. Students are challenged to create a more effective system.
  - Activity # 2 - Water Sheds and Basins A mountain of soil is observed as water is sprinkled and then poured down the valley.
  - Activity # 3 - Water Cycle Terrarium Students make a terrarium out of two-liter pop bottles and observe the water cycle in action.
  - It's Raining in the School An introduction to the concept of the water cycle containing demonstrations on condensation, precipitation and accumulation.

- Wastewater System

  Greater Vancouver Regional District site provides a range of information describing a number of wastewater issues that apply to many cities and towns. The following three links identify common wastewater issues and answers:

- Water

  Over 10 lesson plans/suggested activities for studying water that span grades K-12.

- Water - Facts and Tips

  Health Canada published this page of general information on drinking water and some general tips on water conservation.

- Water Myths and Realities

  This page provides answers to many questions concerning water quality, water sources, and impacts on your health.

- Water Quality Resources

  About 8 lesson plans, activities, and fact sheets on water quality from the Louisiana Department of Environmental Quality. You'll need to scroll down the page to find the links.

- Water Science for Schools

  The U.S. Geological Survey offers a wide range of water science information about water and its uses, its special characteristics and its availability on earth. Included with this information are activities, questions and answers, pictures, maps, data tables and links to further resources.

- Wastershed Game

  Students simulate the role of a manager of a watershed, making decisions in response to issues and then seeing the consequences of those decisions.

- Water, Water Everywhere

  A research project designed for elementary students. Students will gather precipitation levels from two sides of the Cascade Mountains, enter information into spreadsheets, create graphs of the data and discuss the implications of their results.

- Water, Water Everywhere, Nor Any Drop to Drink

  In this lesson plan, grade 6-12 students "investigate the importance of water historically and in their daily lives and examine the nature of water as a limited resource. Students work in groups to research technological systems that have aimed to use water in the most productive ways, evaluate those systems, and create "How It Works" posters of those systems that incorporate their research." They use a New York Times article as a starting point for their explorations.

- Water What-ifs

  This site has a number of lesson plans related to exploring the characteristics of water. Although the site is designed for Delaware and North Carolina teachers, the information and lessons are comprehensive and transferable. Lessons are suitable for both middle and high school students, encourage inquiry and collaboration into the investigation of water quality, and explore the following content areas: pH, temperature, dissolved oxygen, nitrates/phosphates, and macroinvertebrate surveys.

Top of Page

Note: The sites listed above will serve as a source of curricular content in the Water Quality. For other resources in Social Studies - Environment (e.g., curricular content in Biomes, Endangered Species, or Hazardous Waste Disposal), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

CLN Disclaimer

The CLN is an educational portal linking to hundreds of websites on the World Wide Web. Although the sites linked to the CLN have been reviewed and selected by K-12 educators and is intended as an educational resource site for teachers, students and parents, the presence of a link on the CLN does not represent an endorsement of the site by Open School BC. The sites that are listed within CLN are individually responsible for the content and accuracy of the information found in their site.

CanTeach has a new home! The file you are looking for has moved.
Please update your bookmarks.

Your browser will redirect you in a few moments,
or click here to go there now.

**CanTeach has a new home! The file you are looking for has moved.
Please update your bookmarks.**

**Your browser will redirect you in a few moments,
or click here to go there now.**

Earth and Space Science

- Constellations (K-3)
- Graphing Contellations (3+)
- Alternative Snowflakes (K-2)
- Cloud Watching (3+)
- The Sound of Rain (K+)
- Weather Around the World (5+)
- Making a Rainstick (2+)
- Measuring Rain With a Rain Catcher (6+)
- Acid Rain & Plants (Any)
- Where Does the Wind Come From (2+)
- A Variety of Ways to Make a Windsock
- Air Takes Space #1 (2+)
- Air Takes Space #2 (2+)
- Air Takes Space #3 (1-3)
- Rock Collecting (2-4)
- Making Fossils (K-3) (K+)
- Metamorphic Rock: Melting Rocks (K-3)
- Earthquakes(4+)

How the Weatherworks

Activities, Experiments and Investigations

Welcome to our ***Activities, Experiments and Investigations*** index page. These are a sampling of some of our favorite "things" to do in studying about the weather. The listing is far from complete, but it should give you a good idea about how we use weather as a bridge to multi-disciplinary education.

Many of these activities, experiments and investigations are from our published materials (this link takes you to our web store). You are free to use the activities in your classroom. Should you wish to use any of these in any other way, please contact How The Weatherworks™...for permission. THANKS!

Finally, this page has been coded to appear in either Arial or Helvetica font for easier reading. If you do not have either of these fonts installed on your system, the Netscape or Internet Explorer default font should operate. If you encounter any problems reading this page, please contact How The Weatherworks™...

- **NEPHELOCOCCYGIA**
  This activity involves looking for shapes in the clouds. There's also a great interactive language arts activity.
- **SKY WINDOWS**
  What color is the sky or the clouds? Check it out using this "unique" weather instrument. You'll never look at the clouds in the same way again.
- **NOAA WEATHER SATELLITES**
  The National Oceanic and Atmospheric Administration (NOAA), the parent agency of the National Weather Service, launched a new geostationary

weather satellite April 24, 1997 and another May 3, 2000. Weather satellites are a great way to study clouds and cloud patterns from above. HOW THE WEATHERWORKS will be publishing a set of four weather satellite posters in the Fall of 2003.

- **More activities to be posted in the future -- Please come back and check out the latest additions.**

This page was last updated on May 31, 2003.

Home

Guides

" Adventure

" Animals and Nature

" History and Culture

" Maps

" News

" Photography (Wallpapers, More)

" Travel

" Site Index

" For Kids

" For Parents

" For Students

" For Teachers

Photo of the Day

Wallpapers, More >>

REDIRECTING

The National Geographic education site has moved! You are being automatically redirected. Please update your bookmarks to reflect our new Web address (URL).

If you do not see the education site within a few seconds, click here.

NEW: Find Maps, Facts, and Photos

GO!

Search One-Stop Research for our most popular subjects (such as tigers or Egypt) and get results organized by type: pictures, articles, video, maps, and more.

Search for Educational Materials

SUBJECT

RESOURCE TYPE

GRADE

GO!

Search by keyword:

GO!

Or, search our publications index for articles in *National Geographic*, *NG Kids*, and more.

How can we help you teach?

Educator Favorites:
— GeoSpy
— Education Foundation
— Xpeditions
— National Geographic Bee
— Printable Maps
— GeoBee Quiz Game
— Local Geography Alliances
— Calendar of Events
— Grants for Educators
— MapMachine
— News Story of the Day

ONLINE ADVENTURE

Virtual Great Barrier Reef

Dive into Australia's Coral Sea and explore the biodiversity of the Great Barrier Reef. Then read about some of the environmental threats it is currently facing.

MAPS & GEOGRAPHY

Country Profile: Australia

Get maps of Australia, as well as facts and figures detailing the country's history, geography, economy, and more.

Online Adventure
Creature Feature: Koalas
Learn all about these lovable marsupials from down under with this interactive feature—includes koala facts, video, and a map of past and present distribution.

Maps and Geography
The *Real* Man From Snowy River
Experience life in the outback of Australia through the work of Banjo Paterson, the nation's most celebrated poet.

Teacher Community
Join a Geography-Teaching Alliance
Educators, join your local geography alliance to share ideas with colleagues, apply for grants, extend your expertise, and more. Find your state and sign up!

Lesson Plan
Great Barrier Reef
In this lesson students will research Australia's Great Barrier Reef and create brochures promoting responsible tourism in this vital marine ecosystem.

Teacher Store
Australia and Oceania Laminated Wall Map
This fully markable wall map features a political map of Australia and Oceania on one side and a physical map of

— Photo of the Day
— Television Programming
— Geography Action
— Homework Help
— Bookmark Factory
— Encyclopedia
— Editorial Style Manual (PDF)

Extension Sites:
— Windows on Literacy
— Reading Expeditions
— GeoKits

Our Magazines:
— *National Geographic*
— *NG Kids* (formerly *World*)
— *Traveler*
— *Adventure*
— *NG Explorer* (Classroom)

Sign up for our monthly e-mail updates for educators. We'll let you in on our latest lesson plans, ideas for using our content in the classroom, and more.

Free Newsletters >>

LOOKING FOR SCHOOL PUBLISHING PRODUCTS?

• Order a FREE Catalog.
• Browse our Teacher Store.
• Click here for Ordering Information or call:
800 368 2728 (U.S.)
800 268 2948 (Canada)

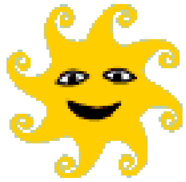
How else can we help?
Let us know!

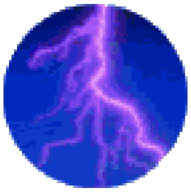
Australia and Oceania on the other. The maps contain statistics about the land and its population as well as other interesting facts.

The National Geographic education home page is updated weekly—check back every Friday!

[Cadet Section](#)

For Grades 2 to 8





[Expert Section](#)

For Grades 6 to 12

[Teachers' Lounge](#)

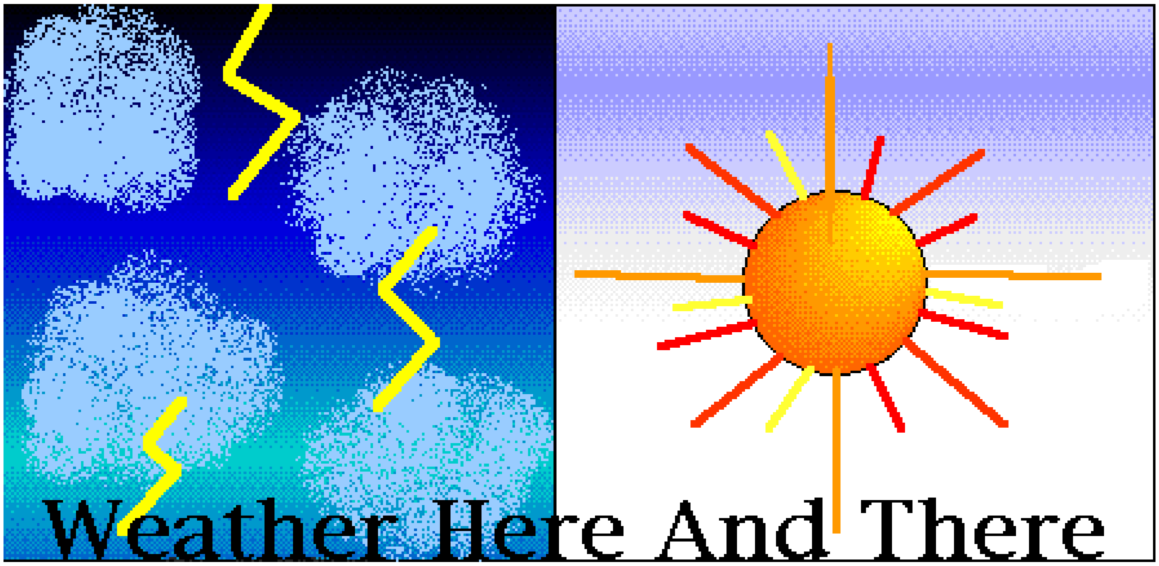
Lesson Plans & Resources

[Parents' Center](#)

Fun With Your Children!

• Register! • KGAN Current Weather •

WeatherEye is a public service of KGAN and is sponsored by Central Iowa Power Cooperative (CIPCO). Click on Louie the Lightning Bug for electrical safety information and the Electric Universe.



BASIC OVERVIEW OF UNIT

WEATHER HERE AND THERE is an integrated weather unit which incorporates interaction with the Internet and hands-on collaborative, problem solving activites for students in grades four through six. This unit is divided into six lessons. The lessons integrate math, science, geography, and language arts in the process of teaching and learning about weather phenomena. Students will become involved in collaborative problem solving using e-mail as well as through joining projects offered via the Internet. *The Global Education Project* will help students see the relevance of science by interacting with scientists and other students across the world, as they collaborate in the study of weather in their environment.

The first three lessons focus on learning basic meteorological concepts about weather elements, how to take measurements using appropriate weather instruments, and recognizing basic weather trends and patterns.

The last three lessons focus on studying weather maps and applying the knowledge and experience about weather to associate weather trends and patterns in the process of making accurate forecasts. The unit culminates with a weather broadcast of a twenty-four hour forecast presented by students and focusing on a network of weather stations in the United States created by the students.

Unit Directory

We'd sure appreciate Your Comments on this web site!

There were quite a few people who contributed to this web site. Please take a moment to read the Credits.

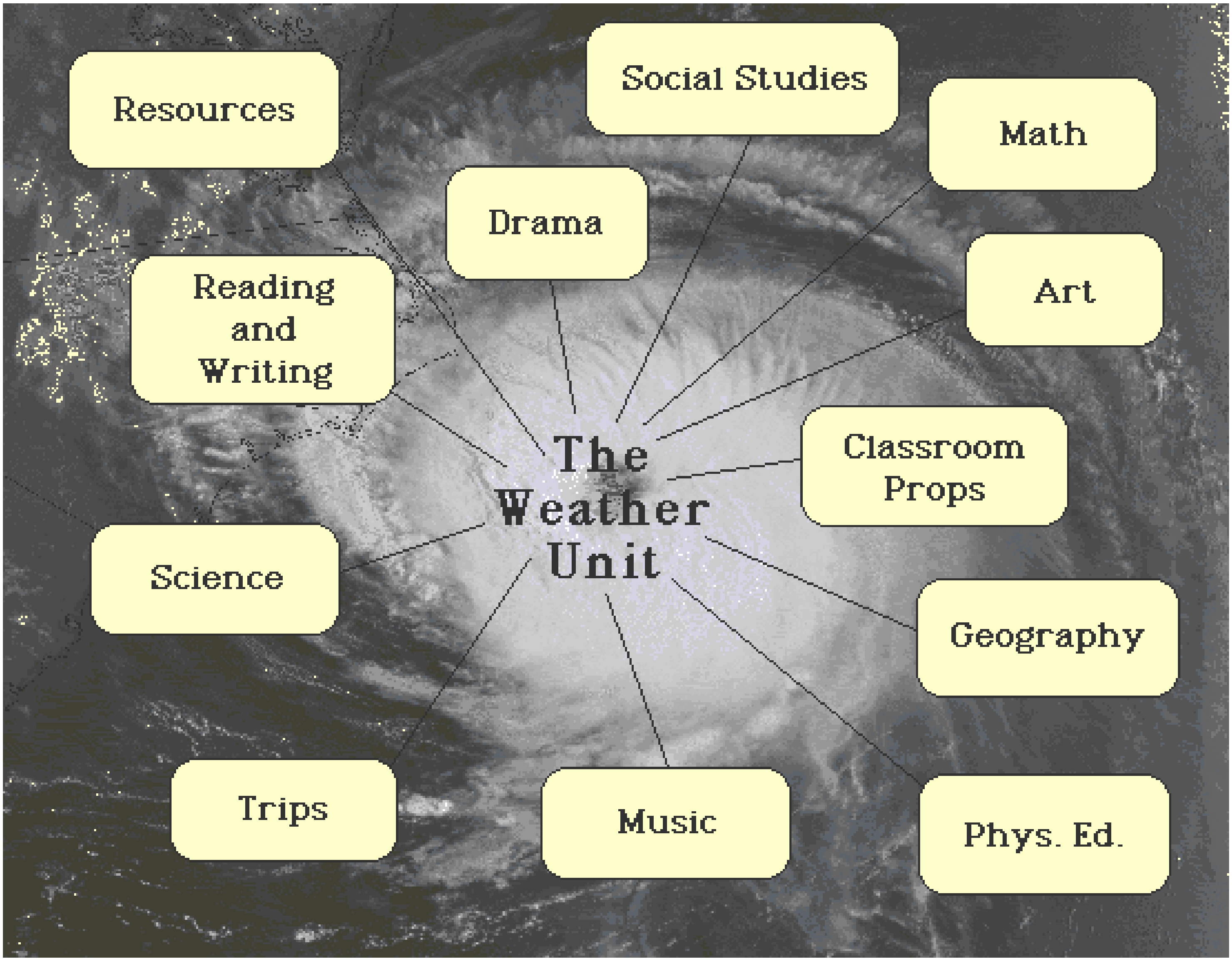
Last updated July 1995.

More lessons like these available at The Curriculum Archive

Teachers! ... click here for an interesting book review project for your students this year!

... click here for global warming resource for your students

The Weather Unit



Welcome to the Weather Unit! Click on a subject heading to view current lessons.

- Math
- Science
- Reading & Writing
- Social Studies

- Geography
- Art
- Music
- Drama
- Physical Education
- Field Trips
- Classroom Props
- Resources
- Other
- More lessons

Looking for a specific lesson? ... try this search engine

Post Comments about the Unit

Read Comments about the Unit

Return to Collaborative Lesson Archive

Teachers! Please visit our new project - The Collaborative Lesson Archive and give us your feedback.

-

Subject Areas

Find what you are looking for by subject. If you don't see your subject here, try a search.

- Aboriginal Studies
- Business Education
- Career Studies
- Current Events
- English/Language Arts
- English as a Second Language
- Environmental Studies
- Fine Arts
- Health, Nutrition, and Personal Planning
- Information Technology
- Mathematics
- Media Literacy
- Multiculturalism
- Physical Education
- Reference Materials
- Science
- Social Studies
- Technology Education

Unspecific Subject Areas

For Kids Only **(.... but for Primary Teachers too!)**	Games, activities, downloadable software, songs, postcards, places to publish...... all for kids. Since these resources address many basic skills, primary teachers will find this part of CLN useful as well.

General Education Resources	Some WWW resources do not fit nicely into the specific subject areas listed above. In this section, you'll find our collection of education directories or "meta-lists" as well as our collection of general lesson plan sites.

Educational Resources in Science

Curricular Resources (Information/explanations for students and teachers wishing to learn more about Science)			
Earth Science • Astronomy (CR) • Geology (CR) • Paleontology (CR) • Weather/ Climate (CR)	General Science • General Science (CR)	Life Science • Life Science (CR)	Physical Science • Chemistry • Physics
Instructional Materials (Lesson plans and teaching tips/ideas for Science teachers)			
Earth Science • Astronomy (IM) • Geology (IM) • Paleontology (IM) • Weather /Climate (IM)	General Science • General Science (IM)	Life Science • Life Science (IM)	Physical Science • Chemistry (IM) • Physics (IM)

Theme Pages
(Curricular resources as well as Instructional Materials on specific Scientific topics)

Air Quality

Asteroids, Comets, and Meteors

Biomes

- Antarctic Theme Page
- Arctic Theme Page
- Drylands/Deserts
- Temperate Forests
- Tropical Rainforests
- Wetlands

Bubbles

Clouds

Dinosaurs

Electricity (Concepts)

Electronics (Circuitry)

El Niño

Famous Canadians

[Simple] Flying Machines

Gardening

Genetics/Biotechnology

Gerbils-Hamsters

Glaciers

Global Warming

Hot Air Balloons

[The] Human Body's Senses

- Hearing
- Sight
- Smell
- Taste
- Touch

[The] Human Body's Systems

- Brain/Nervous System
- Circulatory System
- Digestive System
- Muscular System
- Respiratory System
- Skeletal System

Inventors and Inventions

Kites

Lightning

Magnetism

Natural Disasters

- Avalanches
- Blizzards
- Earthquakes
- Floods
- Hurricanes
- Tornadoes
- Tsunamis
- Volcanoes

Oceanography

Ozone Depletion

Paper Airplanes

Periodic Tables

Pictures

Rocks, Minerals and Mining

Science Fair

Soaps and Soap Making

Sound

Water Quality

Whales

Previous Screen

ACID RAIN

Welcome to this research study on acid rain. You may choose to be a specialist in one of the areas listed below. You may research information in your field, compile data, analyze the data, and then meet with others in your group for their input. You will then write a report on this topic. You may write about information you discovered, and creative ideas about any aspect of this topic.

TEACHER'S PAGE

Click on the subject of your choice:

- CHEMISTRY
- ECONOMICS
- HISTORY
- ENVIRONMENT
- HEALTH
- POLITICS/GOVERNMENT

CHEMISTRY

You have chosen to be a chemist. Your job will be be to find out the chemical make-up and properties of acid rain. Some questions you may want to answer are:

- What is an acid?
- What chemicals make rain into "acid rain", and how?
- Where do the chemicals come from?
- What do the chemicals do to the environment?

click here for resources
click here for Acid Rain ABCs
click here for some great general information
click here for information about pH

click here for reference material on cloud chemistry
click here for information about distillation
click here to read about an artist's solution

Back to the top

ECONOMICS

You have chosen to be an economist. Your job will be to find out effects of acid rain on the world economy. Some questions you may want to answer are:

- What is the world trend in the problem of acid rain?
- What economies are hardest hit, and how?
- What is the estimated cost, in dollars, to economies by acid rain?
- What is the estimated cost of preventing acid rain, or any solutions?

click here for information on acid rain and power stations
click here for information on the Canadian Coalition on Acid Rain
click here for general information on acid rain from Yahoo
click here for some solutions
click here for information about cost of acid rain
click here for information about Bush's Clean Air Act (one view)

Back to the top

HISTORY

You have chosen to be a historian. Your job will be to find out how acid rain has evolved through history in cause and effect. Some questions you may want to answer are:

- Has acid rain or other pollution always been a problem?
- When did acid rain begin to be a problem?
- What are the main contributors (in historical evolution)that cause this problem?
- Are there any lessons to be learned from history?

click here for information about the Mayan Pyramids and acid rain
click here for general information sites
click here for Timework Page
click here for information about the Industrial Revolution
click here to see how volcanoes have produced acid rain through history
click here for more information about acid rain in history

Back to the top

ENVIRONMENT

You have chosen to be an Environmentalist. Your job will be to find out how acid rain effects the environment, water, air, soil, plants or animals. Some questions you may want to answer:

- What does acid rain do to living or non-living things?
- What places are especially vulnerable to acid rain?
- What are the causes of acid rain?
- What are possible preventions or solutions to the problem of acid rain?

click here for yahoo
click here for information on Hydrology
click here for general information
click here for Environmental News Network
click here for information on how acidity affects aquatic organisms
click here for news on the environment
click here for more information about pollution control
click here for information about environment and acid rain
click here to have a scientist answer your questions
click here for effects of acid rain on terrestial habitats
Back to the top

HEALTH

You have chosen to be a researcher in the field of human health. Your job will be to find out possible connections between acid rain and health problems. Some possible questions you may want to answer are:

- How does acid rain affect living things(plants and animals)?
- What non-living things are affected?
- How can human health be affected directly or indirectly?
- How does one reconcile the importance of technology versus human health?

click here for information
click here for government information on acid rain
click here for information on acid rain's effects on human health
click here for information on effects of acid rain on drinking water

Back to the top

POLITICS

You have chosen to be a politician. Your job will be to find out what problems are associated with acid rain, and if these problems could be controlled by legislation, and if so, how this could be done. Some questions you may want to consider are:

- Can one legislate in a fair manner?
- How would you go about it?
- What are the social and economic implications of such legislation?
- How would you deal with what is ethical and moral versus what is popular, as an elected representative. Is what is popular always right, or is what is right always popular?

click here for information about S.E.P.A.State Environmental Policy Act, Washington State
click here for some references
click here for information about government regulations
click here for E.P.A. documents on Acid Rain
click here for general information about acid rain in all categories

Back to the top

Click here for a related site about Acid Rain

E mail Me?
TEACHER'S LINK

U.S. Environmental Protection Agency

Clean Air Markets - Programs and Regulations

Recent Additions | Contact Us | Print Version   Search:

GO

EPA Home > Clean Air Markets > Programs and Regulations > Acid Rain Program

Home | Business | Programs | Progress | Trading | Reports | Data and Maps | Monitoring | Issues

Acid Rain Program

NOx Trading Programs

Monitoring

US - Canada

Acid Rain Program

The overall goal of the Acid Rain Program is to achieve significant environmental and public health benefits through reductions in emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx), the primary causes of acid rain. To achieve this goal at the lowest cost to society, the program employs both traditional and innovative, market-based approaches for controlling air pollution. In addition, the program encourages energy efficiency and pollution prevention.

- Goals
  - Program Overview
  - Nitrogen Oxides (NOx) Reduction Program
- Laws & Regulations
- Guidance and Fact Sheets
  - Affected Sources and Locations
  - Acid Rain Permits
  - Acid Rain Program Policy Manual
  - Emissions Monitoring
  - Reporting Emissions
  - Annual Reconciliation of Allowances and Emissions
  - Applicability Determinations
    legal decisions on how the regulations apply
- Sulfur Dioxide (SO2) Allowances
  - Clearing The Air: The Truth About Capping and Trading Emissions
  - Allowances Fact Sheet
  - SO2 Allowance Data

- Allowance Allocations
- Allowance Auctions
- Allowance Transfers
- Conservation and Renewable Energy Incentives
- Opt-in Program
- Buying Allowances if You're Not A Regulated Source
- SO2 market analysis

- Program Forms

- Related Information
  - Information about acid rain
  - Emissions Data
  - Compliance Reports
    Includes lists of affected sources in each year and the number of allowances banked from each year to the next
  - Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990

CAM Update | Forms | Workshops | Glossary
Site Map | About Us | Questions and Answers | Other Resources

EPA Home | Privacy and Security Notice | Contact Us

U.S. Environmental Protection Agency

Clean Air Markets - Environmental Issues

Recent Additions | Contact Us | Print Version Search:

GO

EPA Home > Clean Air Markets > Environmental Issues > Acid Rain

Home | Business | Programs | Progress | Trading | Reports | Data and Maps | Monitoring | Issues

Acid Rain
Smog/Ozone Transport
Regional Haze
Climate Change
Students and Teachers

Acid Rain

En Español

Acid rain is a serious environmental problem that affects large parts of the US and Canada. This section of the Web site provides information about acid rain's causes and effects, how we measure acid rain, and what is being done to solve the problem.

- What is acid rain and what causes it?
- How do we measure acid rain?
- What are acid rain's effects?
- How do we reduce acid rain?
- Science Experiments
- Learning Activities
- Glossary

- Acid Rain Program Progress Report

- Nitrogen: Multiple and Regional Impacts

- Lesson plans for K-12 from the Texas Natural Resource Conservation Commission EXIT disclaimer

Note: If you're looking for the Student Sourcebook, you've found it! We've combined it with other materials, updated and expanded the information, and reformatted it to cover a broader range of topics.. This page links to all of the information in the original Sourcebook; in many cases, it uses the same text as the Sourcebook.

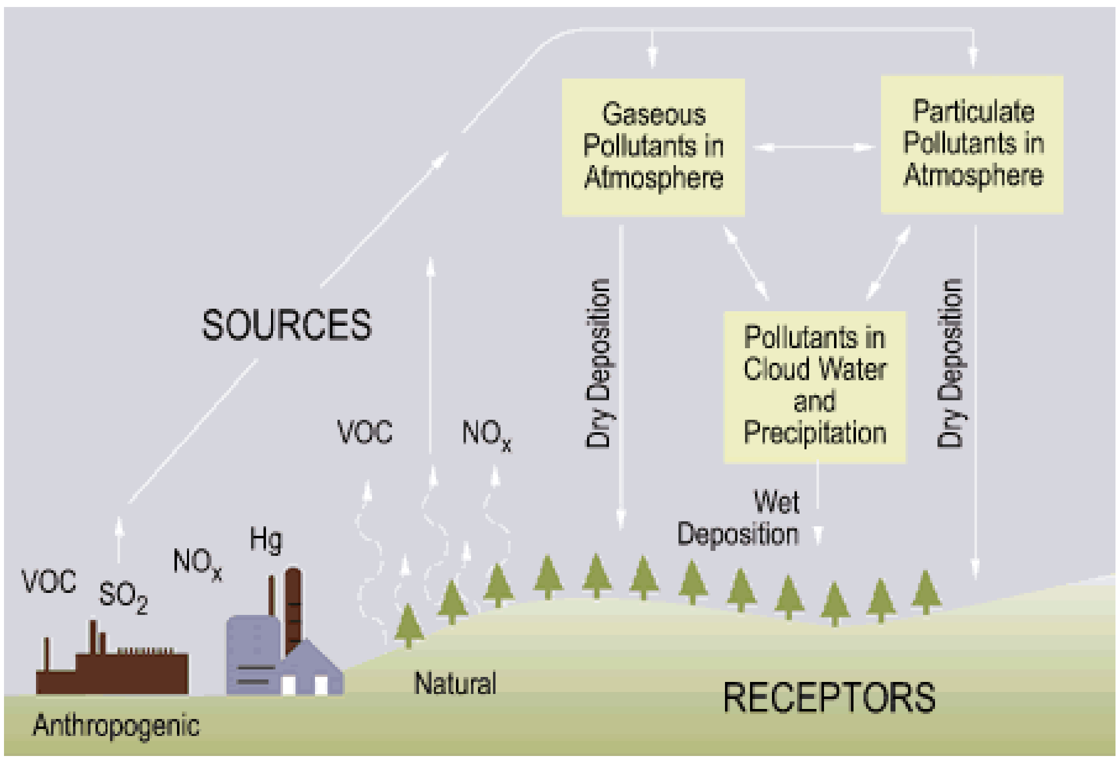
What is Acid Rain and What Causes It?

"Acid rain" is a broad term used to describe several ways that acids fall out of the atmosphere. A more precise term is acid deposition, which has two parts: wet and dry.

Wet deposition refers to acidic rain, fog, and snow. As this acidic water flows over and through the ground, it affects a variety of plants and animals. The strength of the effects depend on many factors, including how acidic the water is, the chemistry and buffering capacity of the soils involved, and the types of fish, trees, and other living things that rely on the water.

Dry deposition refers to acidic gases and particles. About half of the acidity in the atmosphere falls back to earth through dry deposition. The wind blows these acidic particles and gases onto buildings, cars, homes, and trees. Dry deposited gases and particles can also be washed from trees and other surfaces by rainstorms. When that happens, the runoff water adds those acids to the acid rain, making the combination more acidic than the falling rain alone.

Prevailing winds blow the compounds that cause both wet and dry acid deposition across state and national borders, and sometimes over hundreds of miles.



Scientists discovered, and have confirmed, that sulfur dioxide (SO2) and nitrogen oxides (NOx) are the primary causes of acid rain. In the US, About 2/3 of all SO2 and 1/4 of all NOx comes from electric power generation that relies on burning fossil fuels like coal.

Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. Sunlight increases the rate of most of these reactions. The result is a mild solution of sulfuric acid and nitric acid.

How Do We Measure Acid Rain?

Acid rain is measured using a scale called "pH." The lower a substance's pH, the more acidic it is. See the pH page for more information.

Pure water has a pH of 7.0. Normal rain is slightly acidic because carbon dioxide dissolves into it, so it has a pH of about 5.5. As of the year 2000, the most acidic rain falling in the US has a pH of about 4.3.

Acid rain's pH, and the chemicals that cause acid rain, are monitored by two networks, both supported by EPA. The National Atmospheric Deposition Program measures wet deposition, and its Web site EXIT disclaimer features maps of rainfall pH (follow the link to the isopleth maps) and other important precipitation chemistry measurements.

The Clean Air Status and Trends Network (CASTNET) measures dry deposition. Its Web site features information about the data it collects, the measuring sites, and the kinds of equipment it uses.

What Are Acid Rain's Effects?

Acid deposition has a variety of effects, including damage to forests and soils, fish and other living things, materials, and human health. Acid rain also reduces how far and how clearly we can see through the air, an effect called visibility reduction. The acid rain effects section provides more details on each of these.

How Do We Reduce Acid Rain?

- What society can do
- What individuals can do
- What EPA is doing
  EPA's Acid Rain Program limits, or "caps," sulfur dioxide (SO2) emissions from power plants at 8.95 million tons annually, allows those plants to trade SO2 allowances, and reduces nitrogen oxide emission rates.

Experiments & Activities for Students

The experiments page provides detailed instructions and suggestions for classroom activities.

Glossary

The Clean Air Market Programs glossary includes many terms related to acid rain.

Acid Rain

Smog/Ozone Transport

Regional Haze

Climate Change

Students and Teachers

Acid Rain Students Site

Effects of Acid Rain

Acid rain causes acidification of lakes and streams and contributes to damage of trees at high elevations (for example, red spruce trees above 2,000 feet) and many sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints, including irreplaceable buildings, statues,and sculptures that are part of our nation's cultural heritage. Prior to falling to the earth, SO2 and NOx gases and their particulate matter derivatives, sulfates and nitrates, contribute to visibility degradation and harm public health.

The links below provide more detailed information on each of these effects.

- Surface waters (e.g., lakes and streams) and animals living in them
- Forests
- Automotive Coatings (e.g., car paint)
- Materials
- Visibility
- Human Health

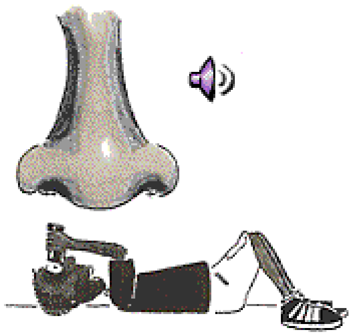
HHMI
HOWARD HUGHES MEDICAL INSTITUTE

AirJunk

Specks, Flecks and Particles in the Air

Have you ever noticed tiny particles floating in the air?

Imagine yourself relaxing.
Your brain controls your breath automatically.
In...Out...
In...Out



The air has oxygen and other chemicals.
But it also carries dust, tiny animals, and other stuff.

Some of this stuff is clinging to the hairs of your nose.

Let's see what's hiding inside your nose.
Warning: This could get messy!

RUN FOR IT!

Click

Adapted from inquire-within take-home-science, Children's Museum, Boston, MA

Cool Home | Plant-Parts | Air Junk | Critters | Butterflies | Inch Square

4000 Jones Bridge Road Chevy Chase, MD 20815-6789 | (301) 215-8500 | e-mail: webmaster@hhmi.org

Texas Natural Resource Conservation Commission

Rules | Calendar | Publications | Forms | About TNRCC | Help

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See Also:

Small Business and Environmental Assistance

Education K-12

Air Lesson Plans

Waste Lesson Plans

TES 1999 Lesson Plans

Air Quality Lesson Plans and Data

How to use these pages

- Acid Rain Lesson (5th grade)
- Acid Rain Information, Activities and Data
- Acid Rain: The Disappearing Statue (2nd grade)
- Harmful Effects of Acid Rain (7th grade)
- Air Pressure Lesson (6th grade)
- Air Pollution Control Lesson (6th through 8th grades)
- Air Pollution Emissions Information, Activities and Data
- Air Pollution Gremlins Math Lesson (1st grade)
- Air Pollution: Visible and Invisible Lesson (4th grade)
- Air: You Can't See It, But It's There Lesson (1st grade)
- Air Quality and Transportation Lesson (2nd grade)
- Air Terms Lesson (5th grade)
- Air Pollution Word Search Activity (Grades 2nd through 6th)
- Air Pollution Word Search Activity (Grades 7th through 12th)
- Carbon Dioxide and Air Pollution Lesson (4th and 5th grades)
- Carbon Monoxide Information, Activities and Data
- Conserving Electricity Lesson (2nd grade)
- Effects of Ozone in the Air Lesson (5th grade)
- Ground-level Ozone Information and Data
- Inversion Lesson (6th grade)
- Lead Information, Activities and Data
- Let's Catch Some Dirt from the Air Lesson (PK and K)
- Meteorology Data and Activity (4th & 5th grades)
- Ozone Lesson (4th & 5th grades)
- Particulate Matter Lesson (Kindergarten)
- Particulate Matter Lesson (4th grade)
- Particulate Information, Activities and Data
- Plants & Oxygen Lesson (2nd grade)
- Temperature Inversion Lesson (8th rade)
- The Awful 8 Lesson (A play for 6th to 8th grades)
- The Day The Air Pollution Gremlins Came To Town Lesson (3rd grade)

- The Path of Pollution Lesson (7th and 8th grades)
- Rain Forest Deforestation (6th grade)
- Ridesharing Lesson (2nd through 8th grades)
- The Rubber Band Air Test Lesson (2nd through 4th grades)
- Wump World Activities (2nd grade)

Environment Canada | Environnement Canada

English

Français

Canada

Important Notices

Avis importants

U.S. Environmental Protection Agency

Cars and Light Trucks

Recent Additions | Contact Us | Print Version Search:

GO

EPA Home > Transportation and Air Quality > On-road Vehicles and Engines > Cars and Light Trucks

- Green Vehicle Guide
- Fuel Economy
- Vehicle Recalls
- Vehicle Standards and Regulations
- Certification and In-Use Compliance
- Inspection and Maintenance (I/M)
- Emission and Fuel Economy Test Data
- Gas Saving and Emission Reduction Devices Evaluation

This Web page and the related pages linked on the left sidebar provide information on controlling emissions from passenger cars and light trucks. This includes consumer information, vehicle standards and reglations, certification and compliance, fuel economy, and test data. For further information or assistance regarding this Web page, please Contact Us.

Index of Topics

- Consumer Information
- Regulations and Related Documents
- On-Board Diagnostics
- Vehicle Service Information
- Vehicle Programs and Compliance Guidance Letters
- Certification and Fuel Economy Information System (CFEIS)
- Motor Vehicle and Engine Compliance Program Fees Information
- Importing Vehicles and Engines
- Related Links

About Portable Document Format Files

Key Topics: Transportation and Air Quality

- Overview: Pollutants and Programs
- Consumer Information
- On-road Vehicles and Engines
- Nonroad Engines, Equipment, and Vehicles
- Fuels and Fuel Additives
- Voluntary Programs
- Transportation and Air Quality Planning
- Modeling, Testing, and Research

Consumer Information

- Green Vehicle Guide (February 2001, EPA420-F-01-006) 8K PDF
- Automobile Emissions: An

Overview (August 1994, EPA400-F-92-007) 86K PDF

- Automobiles and Carbon Monoxide (January 1998, EPA400-F-92-005) 23K PDF
- Automobiles and Ozone (January 1993, EPA400-F-92-006) 65K PDF
- Motor Vehicles and the 1990 Clean Air Act (August 1994, EPA400-F-92-013) 37K PDF
- Milestones in Auto Emissions Control (August 1994, EPA400-F-92-014) 65K PDF
- Tips to Save Gas and Improve Mileage (August 1994, EPA420-F-92-004) 20K PDF
- Your Car and Clean Air: What YOU Can Do to Reduce Pollution (August 1994, EPA420-F-93-002) 69K PDF
- Do You Drive a 1996 or Newer Car or Light Truck? (August 2002, EPA420-F-02-016) 444K PDF
- On-Board Diagnostics: Frequently Asked Questions (August 2002, EPA420-F-02-014) 39K PDF
- Emission Warranty Info: If you just failed an emissions test
  - 1981-1994 Model Year [19K TXT]
  - 1995 and Newer Model Years [25K TXT]

Regulations & Related Documents

- Federal and California Exhaust and Evaporative Emission Standards for Light-Duty Vehicles and Light-Duty Trucks
- Tier 2 Gasoline Sulfur Final Rulemaking

- Tier 1 Standards
- National Low Emission Vehicle Program and Ozone Transport Commission (OTC) LEV
- CAP 2000 (Compliance Assurance Program)
- Federal Test Procedure Revisions
- Certification Short Test
- Durability
- Evaporative Emissions
- On-Board Refueling Vapor Recovery

Proposed Technical Amendments - Test Procedures for Testing Highway and Nonroad Engines and Omnibus Technical Amendments (signed August 16, 2004)

- Fact Sheet: "Proposed Changes to Test Procedures for Nonroad Engines and Heavy-Duty Highway Engines" (EPA420-F-04-046, August 2004) 104K PDF (3 pages)
- Pre-Publication Preamble and Regulations 1.46 PDF (344 pages)
- Technical Support Document: "Test Procedures for Highway and Nonroad Engines and Omnibus Technical Amendments" (EPA420-D-04-004, August 2004) 808K PDF (70 pages)

CAP 2000 (Compliance Assurance Program)

- On March 16, 2004, the EPA Administrator signed a proposed regulation that instructs automotive manufacturers how to conduct the durability procedures used to predict the useful life emissions of new vehicles. This rulemaking fulfills a court mandate issued on October 22, 2002, by the United States Court of Appeals for the District of

Columbia Circuit that ordered EPA to issue new emissions durability regulations. The following documents relate to the durability proposed rulemaking. Please note that the Preamble and Regulations have not yet been published in the Federal Register, and are subject to editorial changes by the Federal Register office.

- Proposed Preamble and Regulations: [415K PDF 190 Pages]
- Proposed Technical Support Document [30K PDF 5 Pages] and Attachments [7,325K PDF 152 Pages]
- EPA Fact Sheet: [104K PDF 3 Pages]

Contact: Linda Hormes (734-214-4502) hormes.linda@epa.gov

- On August 23, 2001 the Administrator issued a denial to the Ethyl Corporation's request to reconsider the CAP 2000 regulation. The Administrator has also denied two other Ethyl petitions to reconsider a Heavy Duty gasoline rule and an OBD/IM rule. The denial document and the cover letter from the Administrator to Kevin Fast, Counsel for Ethyl Corp. are available below:

  - Cover Letter [58K PDF]
  - EPA Response Document to Ethyl Petitions [116K PDF] [178K WPD]

  These and other documents relating to this petition may also be found at EPA's Air Docket #A-96-50, Room M-1500 (mail code 6102), 401 M St. SW, Washington, D.C. 20460. The docket is open from 8:30 a.m. until 5:30 p.m. weekdays. The docket may also be reached by telephone at (202) 260-7548. As provided in 40 CFR Part 2, a reasonable fee may be charged by EPA for photocopying.

- On December 17, 1999, EPA published a Federal Register Notice extending the comment period for accepting comments on the Ethyl petition regarding CAP 2000 to January 14, 2000.
- On November 5, 1999, EPA published a notice in the Federal Register [HTML] requesting comments on the Ethyl petition to reconsider the CAP 2000 regulation. Comments must be submitted by December 20, 1999 to EPA's Air Docket number A-96-50, Room M-1500, 401 M Street SW, Washington DC 20460.
- Petition for Reconsideration of the CAP 2000 Rule [601K PDF]. This petition was filed before EPA Administrator Carol Browner by the Ethyl Corporation in August, 1999. Other documents relating to this petition may be found at EPA's Air Docket #A-96-50, Room M-1500 (mail code 6102), 401 M St. SW, Washington, DC 20460. The docket is open from 8:30 a.m. until 5:30 p.m. weekdays. The docket may also be reached by telephone at (202) 260-7548. As provided in 40 CFR part 2, a reasonable fee may be charged by EPA for photocopying.
- CAP 2000 Final Rule was published in the Federal register on May 4, 1999.
    - Fact Sheet (March 1999,

EPA420-F-99-005)[13K PDF]

    - Final Rule [575K PDF]

  Contact: Linda Hormes (734-214-4502) hormes.linda@epa.gov

- Guidance document and workshop: **NOTE DATE CORRECTION** An EPA guidance document discussing the implementation of CAP 2000 is available in PDF format or in WPD format. This document also announces an informal workshop on Tuesday, May 18th kicking off the implementation of CAP 2000. A PDF map to the workshop is provided here.
- Control of Air Pollution From New Motor Vehicles; Compliance programs for new light-duty vehicles and light-duty trucks. Notice of Proposed Rulemaking, signed 7/15/98
    - Fact Sheet [13K PDF]
    - Summary [2K TXT]
    - Preamble [210K PDF] or [220K WPD]
    - Regulations [350K PDF] or [400K WPD]
    - Correction to "CAP 2000" Preamble:
      Please note that in section IV.B of the CAP 2000 Preamble (Public Participation-Public Hearing) the docket number given is incorrect. The correct docket number is "A-96-50" (rather than A-96-32). Please refer to docket A-96-50 when submitting comments regarding the CAP 2000 proposal.

Other Files

- California State Motor Vehicle Pollution Control Standards; Waiver of Federal Preemption - Notice of Within the Scope Determination (Zero Emission Vehicle Requirement) (Signed January 18, 2001)
  - Federal Register Notice (Published January 25, 2001)
  - January 18, 2001 Decision Document for above Notice [47K PDF] or [118K WPD]

- California State Motor Vehicle Pollution Control Standards; Waiver of Federal Preemption -- Notice of Waiver Decision and Within the Scope Determinations
  - Federal Register: August 5, 1999 (Volume 64, Number 150) [Page 42689-42692] Notice regarding waiver of federal preemption and within the scope determinations. [Read Now]
  - July 28, 1999 Decision Document for 8/5/99 Preemption Waiver Notice [138K PDF] or [190K WPD]
- September 5, 1997 Rule Amending the Test Procedures for Heavy-Duty Engines, and Light-Duty Vehicles and Trucks and the Amending of Emission Standard Provisions for Gaseous Fueled Vehicles and Engines:
- Direct Final Rule [157K TXT] and Notice of Proposed Rulemaking (NPRM) [7K TXT]

  Contact: Mr. Jaime Pagan (734-214-4574) fax:

(734-214-4816) or email: pagan.jaime@epa.gov

- **3-Wheel Vehicles:**
  - Federal Register: March 11, 1998 [Page 11847-11850] Final Rule: Control of Air Pollution From Motor Vehicles and New Motor Vehicle Engines; Increase of the Vehicle Mass for 3-Wheeled Motorcycles [Read Now]
  - Cancellation of 7/3/97 Public Hearing [1K TXT]
  - 6/3/97 Proposed Rule to change the regulatory definition of a motorcycle to include 3-wheeled vehicles weighing up to 1749 pounds [37K HTML]
  - Extension of Interim Revised **Durability** Procedures for Light-Duty Vehicles and Light-Duty Trucks:
    - 8/22/97 Final rule [HTML]
    - 3/21/97 Notice of Cancellation of 3/27 Public Hearing [1K TXT]
    - 3/11/97 Proposed Rule [20K HTML]
    - Removal of direct final rule amendments [4K HTML]

    Durability ftp Directory
  - 10 Gallon Per Minute **Fuel Dispenser Flow Rate** Regulation
    - 6/21/96 Press Release
    - 6/96 Direct Final Rule [17K ZIP

WP5.1] or [42K TXT]

    - 6/96 Proposed Rule [5K ZIP WP5.1] or [6K TXT]
    - Questions and Answers, 11/9/95 Revision, plus Procedures [10K TXT]

- 2/14/96 **Vehicle Import** Amendments Final Rule [40K PDF] (readable tables) or [30K TXT] (unreadable tables)
- August 23, 1995 Evaporative and Refueling Emission Technical Amendments, Final Rule [TXT] or [PDF]
- June 30, 1995 Technical Amendments to the Test Procedures for Methanol-Fueled Motor Vehicles and Motor Vehicle Engines and Petroleum-Fueled Motor Vehicles, Final Rule. [TXT]
- May 1996 Press Release: Hyundai high altitude cars recalled for emission repair [1K TXT]
- July 17, 1992 (57 FR 31888) Interim Regulations for **Cold Temperature Carbon Monoxide** Emissions from 1994 and Later Model Year Gasoline-fueled Light-Duty Vehicles and Light-Duty Trucks
    - Preamble [98K PDF] or [75K WP5]
    - Regulation [217K

PDF] or [234K WP5]

- **Directory of These & Related Documents** [Index]

Related Links

EPA Links

- Advanced Automotive Technology and the Clean Automotive Technology Program
- Fuel Cells and Vehicles
- Gasoline Fuels
- Alternate Fuels
- MOBILE Model for On-Road Vehicles
- Motor Vehicle Air Conditioning Information for Consumers
- Motorcycles

External Links

EXIT disclaimer

- National Center for Vehicle Emissions Control and Safety (NCVECS)
  Colorado State University
  This Web site provides information about NCVECS as well as topics and issues related to mobile sources. Topics covered include: light-duty vehicle emissions research, on-board diagnostics II, automotive emissions repair tips, automotive technician training issues, and basic and enhanced inspection/maintenance program issues.
- Best Workplaces for Commuters
  EPA and the U.S. Department of

Transportation (DOT)
The Best Workplaces for Commuters program was established by EPA and DOT to recognize employers who voluntarily meet the *National Standard of Excellence* in employer-provided commuter benefits. Providing commuter benefits helps employers address limited or expensive parking, reduce traffic congestion, improve employer recruiting and retention, and minimize the environmental impacts associated with drive-alone commuting. The Web site provides information on the program for employers, employees, supporters, and commuters.

- Mobile Source Program
  California Air Resources Board (CARB)
  This Web page provides links to information on numerous topics related to reducing pollution from cars and light trucks, including: a buyer's guide to cleaner cars, the California Motor Vehicle Service Information Program, carpool lane access, the Emission Inventory Program, evaporative emission controls, in-use testing of motor vehicles, and the smoking vehicles hotline.

LET'S TALK ABOUT HEALTH AND AIR QUALITY

Canadians are becoming increasingly aware of and concerned about the future health of the environment, and in particular the quality of the air. Although some hazardous contaminants in the air, such as lead, have declined in recent years, others remain and continue to become more problematic. Canada is a large industrialized country, responsible for the release of a variety of pollutants into the air. In addition to this, certain areas of Canada are located downwind of industrialized areas of the U.S., with resultant higher levels of pollution. Despite this, Canadians enjoy good air quality when compared to many other countries.

However, evidence gathered over the last ten years has increased concerns about the health effects of air pollutants. As a result governments and the public have increasingly focussed on this area.

- The Quality of our Air
- Major Air Pollutants
- Smog
- Acid Rain
- Climate Change

The Quality of our Air

Air is a mixture of gases that surrounds the earth and makes up our atmosphere. Pure air consists of 21% oxygen and 78% nitrogen by volume, plus traces of other substance and gases both natural and anthropogen (man-made). The air that we breathe may actually contain thousands of chemical and biological substances. Many of these are pollutants such as: ground-level ozone (O_3), total suspended particulate (TSP), fine particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) or particles less than 10 microns in diameter (PM_{10}), sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOCs), sulphate (SO_4), and nitrates (NO_3).

The most commonly measured outdoor air pollutants in Canada include ground-level ozone, particulate matter, carbon monoxide, sulphur dioxide and nitrogen oxides. These substances are the principal ingredients or precursors of smog, and some also contribute to acid rain.

Additional air pollutants of concern include toxic metals (lead, mercury, cadmium, manganese, etc.), and compounds such as benzene, formaldehyde, polychlorinated biphenyl's (PCBs), dioxins, and other persistent organic compounds.

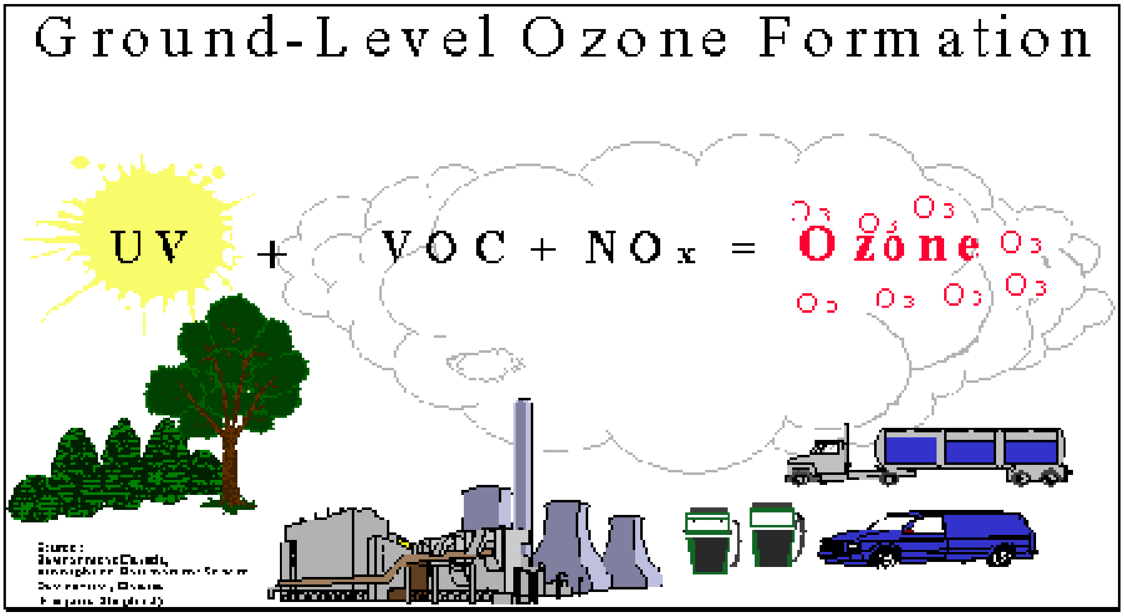
Major Air Pollutants

Outdoor air contaminants come from both natural and human sources. Natural sources include smoke from forest fires, wind-blown dust from soil and volcanoes, bacteria, fungi and chemicals released by plants and animals. However, air pollution is primarily associated with everyday human activities. Pollutants are released by motor vehicles, industrial processes (pulp and paper mills, ore smelters, petroleum refineries, power generating stations and incinerators), and the burning of fossil fuels such as gas, oil, coal and wood.

Air pollutants can be carried thousands of miles across borders and oceans or from one urban area to another. This phenomenon is common around the world and is referred to as "long-range atmospheric transport" or "transboundary pollution".

- Ground-level ozone (O_3)
- Nitrogen Oxides (NOx)
- Volatile Organic Compounds (VOCs)
- Sulphur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Airborne particles (PM)
- Other contaminants

Ground-level ozone (O_3)



Ozone is a naturally occurring gas in the lower atmosphere that increases in concentration when volatile organic compounds (VOCs) and nitrogen oxides (NOx) react in the presence of sunlight and stagnant air. High levels of ground-level ozone often occur during hot summer days in or downwind of heavily populated areas, where sources emit the necessary VOCs and NOx to produce ozone.

Ground-level ozone, a primary component of smog, differs markedly from the protective blanket of ozone high above the earth (also known as the 'ozone layer' or 'stratospheric' ozone), which acts to shield the Earth's surface from intense ultraviolet radiation produced by the sun.

Ground-level ozone has been linked with a broad spectrum of human health effects. Because of its reactivity, ozone can injure biological tissues and cells. Exposure to ground-level ozone for even short periods at relatively low concentrations has been found to significantly reduce lung function in healthy people during periods of exercise. This decrease in lung function is generally accompanied by other symptoms including tightness of the chest, pain and difficulty breathing, coughing and wheezing. The data on health effects of ozone have been examined in human epidemiological studies and exposure to ozone has been associated with mortality, hospital admissions, emergency department visits, and other adverse health effects.

Nitrogen Oxides (NOx)

Nitrogen oxides include a number of gases that are composed of oxygen and nitrogen. In the presence of sunlight these substances can transform into acidic air pollutants such as nitrate particles. The combustion of fuel for transportation, home, and industrial use accounts for approximately 94% of the emissions of nitrogen oxides produced by human activities in Canada. The nitrogen oxides family of gases can be transported long distances in our atmosphere. Nitrogen oxides play a key role in the formation of smog (ground-level ozone). At elevated levels, NOx can impair lung function, irritate the respiratory system and, at very high levels, make breathing difficult, especially for people who already suffer form asthma or bronchitis.

Volatile Organic Compounds (VOCs)

Volatile organic compounds are a group of carbon-containing compounds that tend to evaporate quickly at ordinary temperatures. VOCs are present in our atmosphere at very low levels. Generally, VOCs are found in higher concentrations indoors than outdoors. VOCs can react with nitrogen oxides to form ground-level ozone. Thousands of natural and synthetic chemicals are VOCs, including benzene which is a natural component of crude oil and petroleum products. Some VOCs are carcinogenic, such as formaldehyde and benzene, and some are irritants as a group of precursors to ozone.

Sulphur dioxide (SO_2)

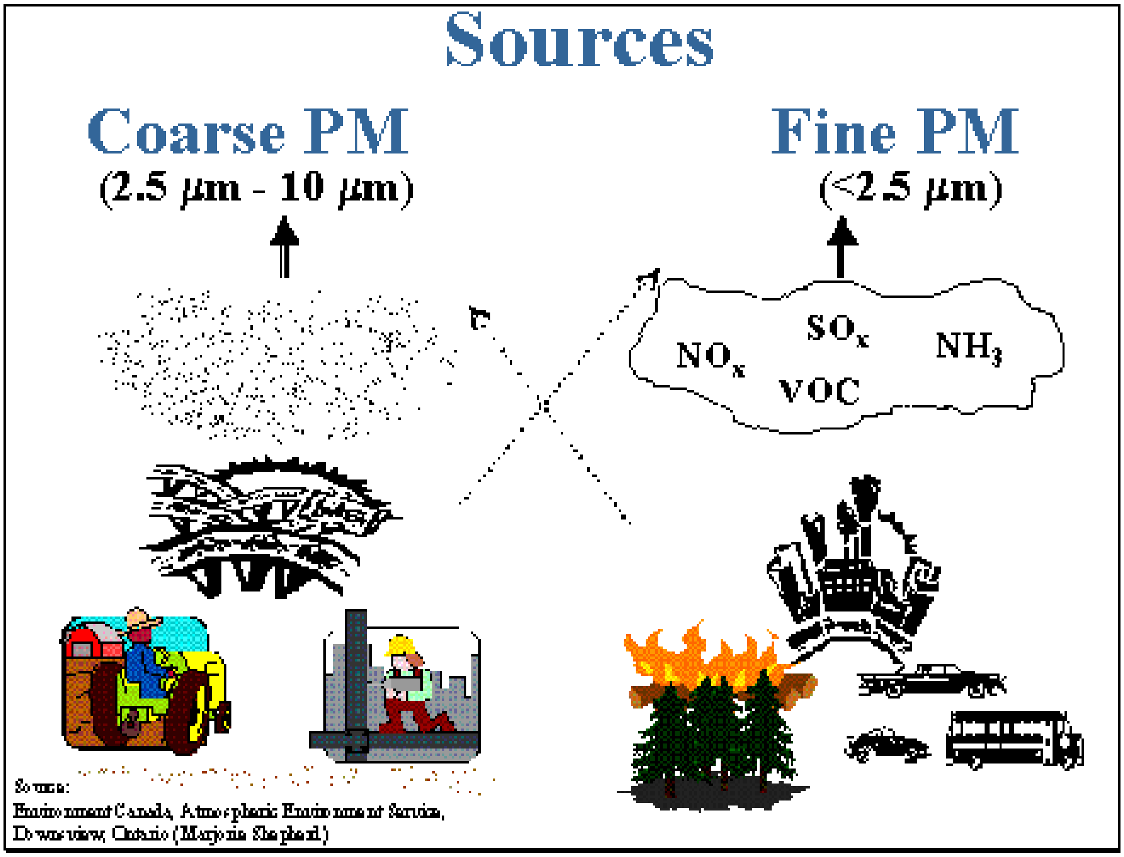
SO_2 is a naturally occurring substance that becomes problematic at higher concentrations. Like nitrogen oxides, sulphur dioxide is produced primarily by industrial processes and fuel combustion. SO_2 can be chemically transformed in the atmosphere in the presence of other chemicals and sunlight to form acidic pollutants such as sulfuric acid and sulphates. SO_2 is a common air pollutant found in outdoor environments. SO_2 can cause breathing problems in people with asthma, but at relatively high levels of exposure. There is some evidence that exposure to elevated SO_2 levels may increase hospital admissions and premature deaths.

Carbon Monoxide (CO)

The principal human source of CO is from fuel combustion, primarily vehicles. CO concentrations are much higher in urban areas due to the number of human sources, although this gas is also released by natural sources such as volcanoes and forest fires. It is an odourless gas which when inhaled, reduces our body's ability to use oxygen. Health effects associated with relatively low-level, short-term exposure to CO include decreased athletic performance and aggravated cardiac symptoms. At the levels typically found in large cities, CO may increase hospital admissions for cardiac diseases, and there is also evidence of an association with premature deaths.

For more information regarding relevant issues, see the Meteorological Service of Canada (Environment Canada)

Airborne particles



Airborne particles are known as 'particulate matter (PM)'or simply 'particles'. These particles are very small solids and/or liquids that are produced by a variety of natural and man-made sources. Airborne particles vary widely in their chemical composition and size.

The size of particles may range from 0.005 µm to 100 µ m in diameter. The suspended portion (total suspended particulates or TSP i.e. found floating in air) is generally less than 40 µm. PM_{10} are particles that are 10 µm or less in diameter. PM_{10} are split into two portions; coarse particles ($PM_{2.5-10}$) and fine particles ($PM_{2.5}$). $PM_{2.5}$ are particles of 2.5 µm or less in diameter. The finer particles pose the greatest threat to human health because they can travel deepest into the lungs. Particles are also an important component of smog. Short-term exposure to airborne particles at the levels typically found in urban areas in North America is associated with a variety of adverse effects. Particulates can irritate the eyes, nose and throat and cause coughing, breathing difficulties, reduced lung function and an increased use of asthma medication. Exposure to particulates is also associated with an increase in the number of emergency department visits, an increase in hospitalizations of people with cardiac and respiratory disease and in premature mortality.

Other air contaminants

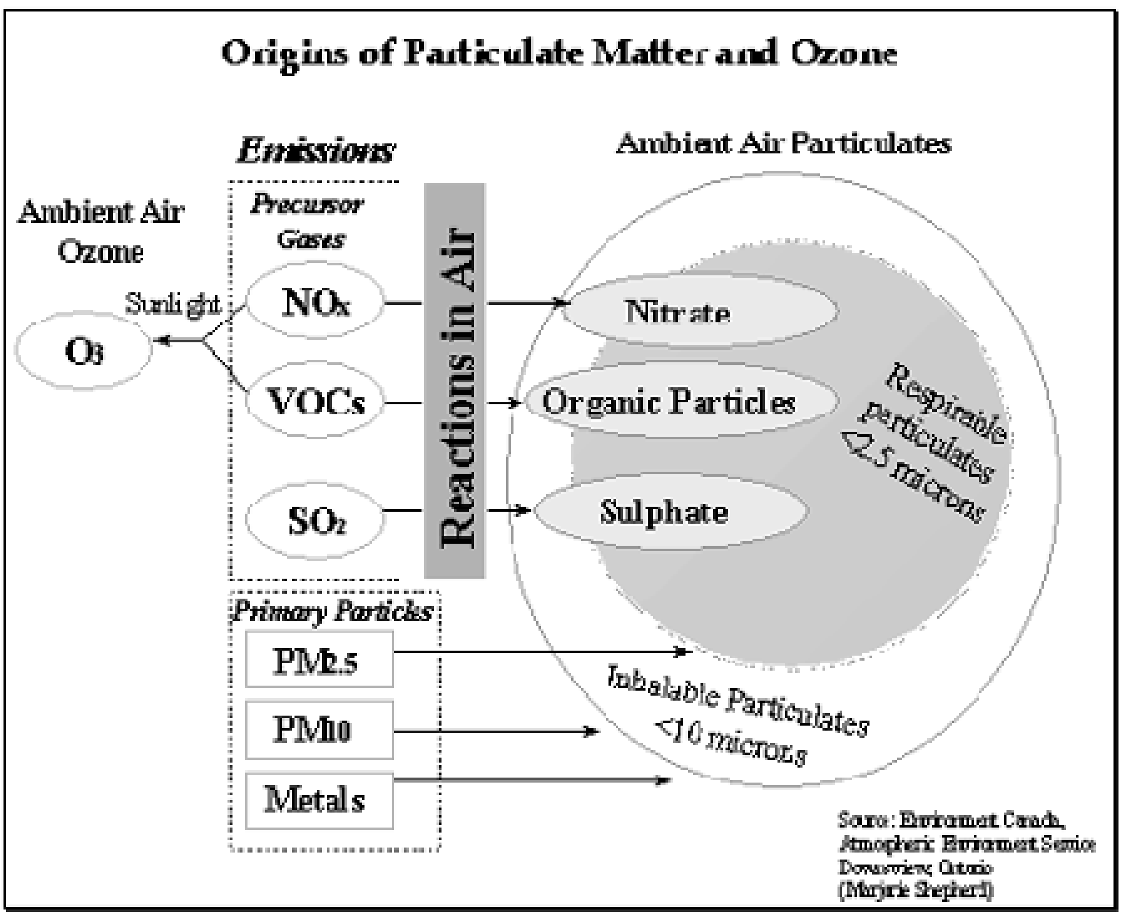
A variety of other contaminants can be found in our air such as hydrogen sulphide (H_2S), total reduced sulphur (TRS) compounds, toxic metals (cadmium, chromium, nickel, manganese), formaldehyde, polychlorinated biphenyls (PCBs), dioxins, and other persistent organic pollutants (POPs). Each is released by human sources and associated with direct effects on human health.

Smog

The term smog was first used to describe the combination of smoke and fog in the atmosphere. In recent years it has become the term given to the chemical soup that is often visible as a yellow-brown haze that hangs over many cities on calm summer days. Smog is a mixture of airborne chemicals which originate from or are produced by motor vehicle and industrial pollution.

A major component of smog is ground-level ozone (O_3), which is formed when two main pollutants, nitrogen oxides (NOx) and volatile organic compounds (VOCs) react in sunlight and stagnant air. Airborne particles such as fine particles or sulphates are also an important component of smog. Because smog formation depends on heat and sunlight, smog generally peaks in late afternoon and early evening. Smog is most obvious in large cities, although suburban and rural communities are not spared. The Windsor-Quebec corridor, the Atlantic provinces and the Lower Fraser Valley in British Columbia have the most smog episodes in Canada.

Breathing in smog has adverse and varied consequences for human health with the cardio-respiratory system being the main target of concern. Wherever its location and whether visible or not, smog is hazardous to human health.



For more information on smog issues, consult the Clean Air website from

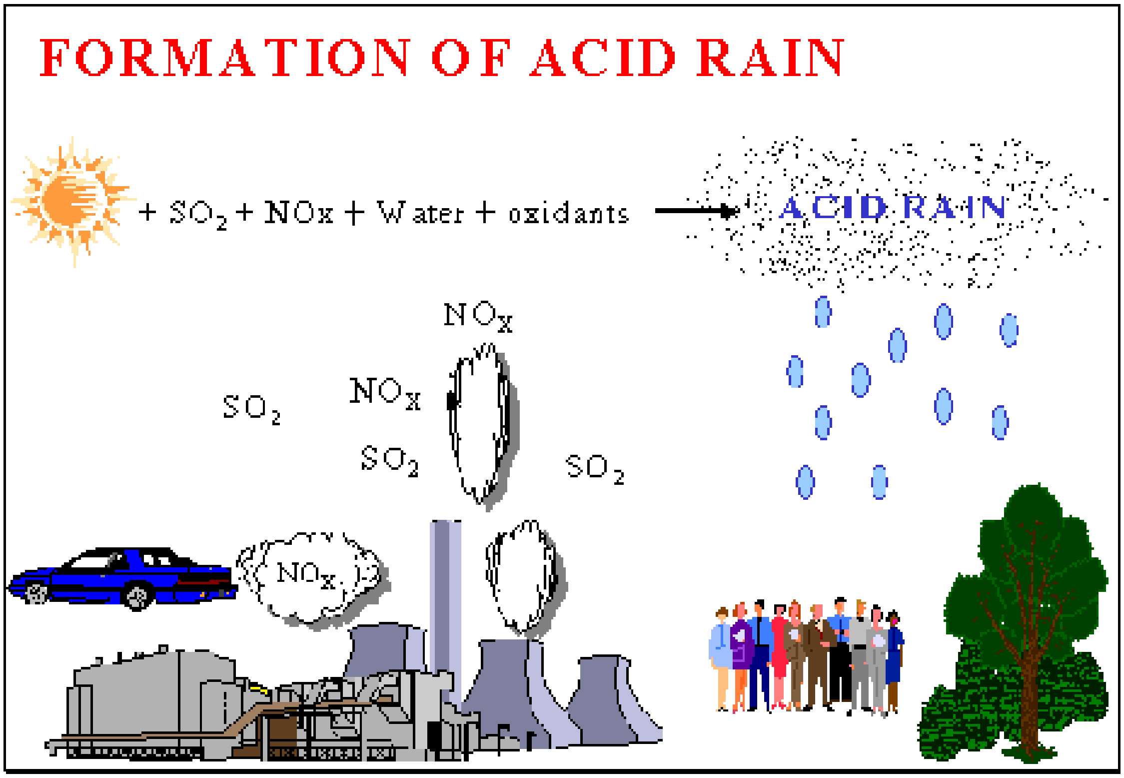
Environment Canada

You can also find more information on this topic at the following sites:

- Smog - It's Your Health
- OMA-Smog

Acid Rain

Air pollution from the burning of fossil fuels is the major cause of acid rain. Acid rain is the popular name for precipitation acidified by atmosphere pollutants. Acid rain is caused by pollutants such as nitrogen oxides (NOx) and sulphur dioxide (SO_2), which in the atmosphere are converted chemically to nitric acid and sulphuric acid. Diluted forms of these two acids fall to earth as rain, or snow.



More than 90% of the NOx and SO_2 emissions occuring in North America are due to human activities. Acidic pollutants may be transported over great distances by winds and weather systems. It is estimated that more than 50% of the acid rain falling in Southern Ontario and the Atlantic region come from U.S. sources.

Acid rain can affect lakes, forests, materials such as buildings and cars and human health. The health concerns related to acid rain are derived primarily from the precursors SO_2 and NOx. In the air SO_2 can react with water and other chemicals to form very fine particles. NOx is a precursor of ozone and particles.

For more information on this topic:

- Environment Canada
- EPA-Acid Rain Program

Climate Change

Human activities are affecting the Earth's atmosphere in ways we have never experienced before. The emissions of greenhouse gases into the atmosphere have increased at a rapid rate during the past few decades and the large scale combustion of fossil fuels is currently one of the biggest contributing factors affecting this kind of change. The principal greenhouse gases are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Chlorofluorocarbons (CFCs)
- Nitrous oxide (NOx)
- Ozone (O_3)

These gases have the ability to absorb infrared radiation from the sun and to trap this energy. The trapping of this heat is known as the greenhouse effect, which results in a global warming of the atmosphere with various impacts on Earth. Each of these greenhouse gases has unique sources and characteristics. Carbon dioxide is the most common greenhouse gas and is responsible for about half of the atmospheric heat retained by greenhouse gases. The effects of global climate change include more frequent heat waves, unstable weather systems, violent and more frequent weather events (storms, hurricanes, floods), threats to food and water supplies, change in vector-borne disease distributions, among other things. The implications for human health are enormous.

Consult the Climate Change and Health Office for more information on the health effects of climate change

For more information on this topic :

- Environment Canada
- Government of Canada - Climate Change

Last Modified 2003-12-11 Important Notices

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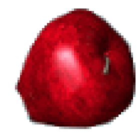
Your Comments

General Environmental Issues and Links
Air Quality Resources
Radiation Protection Resources
Solid Waste & Recycling Resources
Hazardous Waste Resources
Water Quality Resources



General Environmental Issues and Links

- Lesson Plan: Environmental Rulemaking - Background
- Lesson Plan: Environmental Rulemaking - Exercise
- Louisiana Resource Center for Educators (LRCE)
- Louisiana Office of Environmental Education
- EPA Explorers Club for Kids
- EPA Students and Teachers Page
- EPA EPA Region 7 Kids' Page
- EPA Educational Resources
- National Institute of Environmental Health Sciences
- Environmental Education on the Internet

Air Quality Resources

- Lesson Plan: Making Smog in a Jar
- Lesson Plan: Read My Data!
- Facts, Fun, and Activities from the SMOGINATOR!
- EPA Explorers Club for Kids - Air
- EPA Air and Radiation Protection

Radiation Protection Resources

- Fact Sheet and Radon Ranger Comic Book
- EPA Radiation Protection Division Students' Page

Solid Waste & Recycling Resources

- Did You Know? - Landfills
- Edible Landfill
- Did You Know? - Paper
- Activity: Making Recycled Paper
- Did You Know? - Earthworms
- Activity: Making a Worm Farm
- An A-Mazing Recycle Puzzle
- Earth Day Word Puzzle
- Lesson Plan: Solid Waste - Where It Comes From...
- Lesson Plan: Solid Waste - Composting Project
- Activity: Make a Worm Farm
- Activity: Worm Farm Word Puzzle

- Fact Sheet: Why Should I Buy "Recycled"?
- Fact Sheet: Household Hazardous Material - Survey Your Home
- Make Ornaments from Greeting Cards
- What About Paint?
- Activity: Recycled Greeting Card Project
- EPA Explorers Club for Kids - Recycling
- EPA's Recycling Page
- EPA Wastes Kids Page
- East Baton Rouge Recycling

Hazardous Waste Resources

- Learn About Chemicals Around Your Home
- How Hazardous Waste Sites Are Cleaned Up
- Examples of Hazardous Waste Site Cleanup Methods
- EPA Solid and Hazardous Page for Students and Teachers
- EPA Superfund Program - Pages for Students and Teachers

Water Quality Resources

- Planning a School Yard Habitat for St. Thomas More School
- St. Thomas More Schoolyard Habitat Project Update MSPowerpoint 43 slides (2444K)
- Lesson Plans: Water Fit For A Bug
- Lesson Plans: Liquid Assets - Our Water Resources
- Lesson Plan: Safe Drinking Water - Build a Model Aquifer
- Lesson Plan: Safe Drinking Water - Water Filtration
- Activity: Make a Water Cycle Model
- Fact Sheet: The Water Facts of Life

- Fact Sheet: Water Waste Bloopers
- Activity: Paint a Storm Drain - Stencil Project
- EPA Explorers' Club for Kids - Water
- EPA's Office of Water - Kids' Page
- EPA's Office of Water - Nonpoint Sources Kids' Page
- Vermilion/Teche Blue Thumb Project
- Protecting Water.com
- National Year of Clean Water -
- Elementary Ground Water Fact Sheet
- Elementary Surface Water Fact Sheet
- Middle School Ground Water Fact Sheet
- Middle School Surface Water Fact Sheet
- High School Ground Water Fact Sheet
- The Groundwater Foundation Recharge Report for Kids

The National Year of Clean Water (YOCW) is a celebration of thirty years with the Federal Clean Water Act (CWA). The Clean Water Act was enacted by Congress and signed into law by President Nixon in October 1972. Since that time, tremendous strides have been made in the area of water quality improvement throughout Louisiana and the Nation. For more information on the Year of Clean Water please visit the National YOCW Website at http://www.yearofcleanwater.org/. Keep checking this location for more information on what's been done in the past thirty years to improve Louisiana's water quality, what's currently being done, and what's in store for this years celebration. For more information regarding the Year of Clean Water in Louisiana please contact Al Hindrichs.

All pages herein best if read using MS Internet Explorer or Netscape version 6 or greater.

[Home] [Hotlines] [Educational Resources] [Pre-Permit Meetings] [Small Business Assistance] [Recycling] [Litter]
[Environmental Leadership Program] [Earth Day] [Hazardous Waste Reporting] [Lead Program] [Asbestos in the Home] [Waste Tires]
[Medical Waste Alert] [It's The Law] [Building a New State/EPA] [Medicals Waste Incinerators at Hospitals]

Send e- mail to webmasterdeq@LA.GOV or any member of our WWW Task Force
with questions or comments about this web site. To contact us by phone or mail,
see our Office Address/Phone listing.

Health Canada

It's Your Health

Health Canada Home

- About IYH
- Diseases
- Environment
- Food
- Lifestyles
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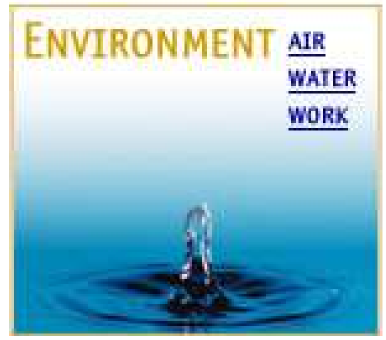

U.S. Environmental Protection Agency

Air - Indoor Air Quality (IAQ)

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IAQ Design Tools for Schools

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IAQ in Large Buildings

Just for Kids!

Partnership for Clean Indoor Air

Homeland Security and Indoor Environments

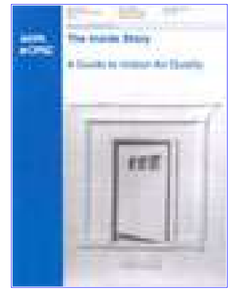
Indoor Air Quality TOPICS

Asthma | IAQ Tools for Schools | Mold | Radon | Smoke-free Homes

ASTHMA

Asthma afflicts about 20 million Americans, including 6.3 million children. Since 1980, the biggest growth in asthma cases has been in children under five. In 2000 there were nearly 2 million emergency room visits and nearly half a million hospitalizations due to asthma, at a cost of almost $2 billion, and causing 14 million school days missed each year.

Read More...



"All of us face a variety of risks to our health as we go about our day-to-day lives. Driving in cars, flying in planes, engaging in recreational activities, and being exposed to environmental pollutants all pose varying degrees of risk. Some risks are simply unavoidable. Some we choose to accept because to do otherwise would restrict our ability to lead our lives the way we want. And some are risks we might decide to avoid if we had the opportunity to make informed choices. Indoor air pollution is one risk that you can do something about."

"The Inside Story: A Guide to Indoor Air Quality"

[Interagency Committee on IAQ (CIAQ)]

[IAQ TOOLS FOR SCHOOLS]

Twenty percent of the U.S. population, nearly 55 million people, spend their days in our elementary and secondary schools. In the mid-1990s, studies show that 1 in 5 of our nation's 110,000 schools reported unsatisfactory indoor air quality, and 1 in 4 schools reported ventilation -- which impacts indoor air quality -- as unsatisfactory. Students are at greater risk because of the hours spent in school facilities and because children are especially susceptible to pollutants. [Read More...]

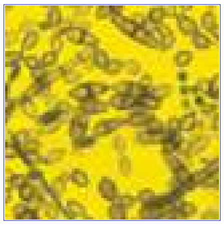
The 5th Annual *Indoor Air Quality Tools for Schools* National Symposium is December 2-4, 2004 at the Grand

[Building Air Quality Guidance]

Hyatt Hotel in Washington, DC.
Read More...

Read about Mercury in schools...

Read about our web-based tool - ***IAQ Design Tools for Schools*** - which provides both detailed guidance as well as links to other information resources to help design new schools as well as repair, renovate and maintain existing facilities.



MOLDS Molds are part of the natural environment. Molds reproduce by means of tiny spores; the spores are invisible to the naked eye and float through outdoor and indoor air. Mold may begin growing indoors when mold spores land on surfaces that are wet. There are many types of mold, and none of them will grow without water or moisture. Read More...

RADON You can't see radon, you can't smell it or taste it, but it may be a problem in your home. Radon is estimated to cause many thousands of deaths each year. That's because when you breathe air containing radon, you can get lung cancer. In fact, the

Surgeon General has warned that radon is the second leading cause of lung cancer in the United States today.
Read More...

SMOKE-FREE HOMES

Secondhand smoke affects everyone, but children are especially vulnerable because they are still growing and developing. EPA has created a national Smoke-free Home Pledge Initiative to motivate parents to protect their children.
Read More...

Take the Smoke-free Home Pledge Today!

The Partnership for Clean Indoor Air, was launched at the World Summit on Sustainable Development in Johannesburg to address the increased environmental health risk faced by more than 2 billion people in the developing world who burn traditional biomass fuels indoors for cooking and heating. According to the World Health Organization, their increased exposure results in an estimated 2 million premature deaths each year, largely among women and children.
Read More...

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Air Quality

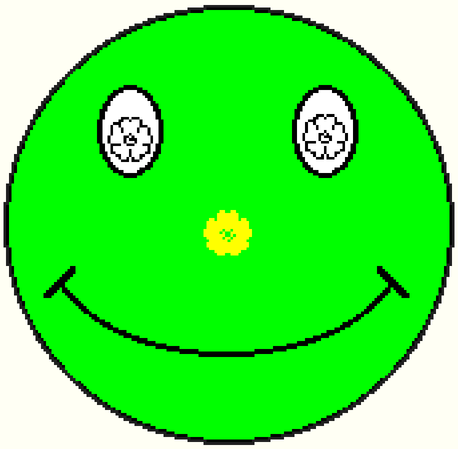
1. **Project A.I.R.E.**

   Project A.I.R.E (Air Information Resources for Educators) was developed by EPA to focus the attention of elementary, junior high, and high school students on air pollution issues. The units in this package encourage students to think more critically and creatively about air pollution problems and the alternatives for resolving them. Topics covered include: air quality, rainforests, radon, the creation of environmental laws, the greenhouse effect and ozone.
2. **Tools for Schools**, grades K-3

   Indoor Air Curriculum
3. **Office of Air Quality** EXIT disclaimer

SMILE PROGRAM BIOLOGY INDEX

The SMILE website is hosted by the Illinois Institute of Technology



The following is a collection of almost 200 single concept lessons. These lessons may be freely copied and used in a classroom but they remain the copyright property of the author(s) and the directors of the SMILE program.

The Biology lessons are divided into the following categories: Anatomy & Physiology, Zoology, Botany, Microbiology, Genetics, Environmental Studies and Ecology, Biochemistry, General Biology and Miscellaneous.

Anatomy & Physiology

- Gathering data about respiration by Charles Buzek - John Spry School
- Production of Sound by Valvasti Williams Jr. - Perkins Bass Elementary School
- Feely Balloons by Winnie Koo - Ravenswood School
- Investigating the Nervous System by Barbara J. Baker - Doolittle West Primary
- What Happens When You Eat? by Kelly Ludwig - Lincoln-Way High School
- Taste, Smell, Touch by Rocenetta Jacobs - Roswell B. Mason Elementary School
- Name That Taste by Gracie L. Jones - Charles Carroll Elementary
- Breathing Is Essential to Life by Dianne Mehlinger - Arthur Libby School
- Sound and hearing by Cecile Savage - John Farren School
- Bones, Bones, and More Bones by Juliette Walker - Crown Community Academy
- An Introduction to the Senses by Therese R. Tobecksen - St. Andrew the Apostle
- Making and Using a Gel Person to Teach Human Anatomy by Kelly Ludwig - Lincoln-Way High School
- Give Me A Hand, I'm "Thumb-body" Special by Ranada L. Johnson - Horace Mann Elementary
- Measuring Work by Cynthia Clemons - John Palmer
- Exploring the Left and Right Sides of the Brain by Kathleen Hall - Goethe School
- Immunity and Disease by Gregory Carter - William King Elementary

- Healthy Colon with Good Digestion and Fiber by Lenora Jean Black - Parkmanor School
- Ears and Hearing by Angelica Wright - Robert Fulton
- Staying Young with Vitamin E by Kelly Ludwig - Lincoln-Way High School
- Rubber Egg by Angel Lee Gilbert - Douglass Middle Academy
- Learning the Bones and Muscles of the Head and Face by Charles T. Buzek - John Spry School
- Straight from the Heart by Cheryl L. Trammell - Delano Elementary School
- Respiratory System by Mona Turner - Delano Elementary School
- Mechanism of Vision by Celestine Miller Jeffreys - Beethoven School
- Movement Across the Membrane (Diffusion) by Kelly Ludwig - Lincoln-Way High School
- The Five Senses by Ollie L. Jamison - Delano Elementary School
- Cervical Vertebrae by Angel Lee Gilbert - Douglass Middle Academy
- Da I's Have It: A Fun Look At The Eye by Ann Fultz - Charles Holden Elementary
- Learning the Dissecting Planes by Charles T. Buzek - John Spry School
- Some Activities For Teaching the Mechanics of Vision by Charles T. Buzek - John Spry School
- Inhalation and Exhalation by Kelly Ludwig - Lincoln-Way High School
- Fingerprints--2 mini-teaches and a game by Russ Osantowski - Carter Elementary
- MuscleMania by Celestine Miller Jeffreys - Beethoven Academic Center
- Breathe In, Breath Out by JoAnn Brooks-Williams - Overton Elementary
- Listen To Your Heart Beat by Lula Carey - Overton School
- Internal Anatomy: A Fun Look At The Digestive System by Ann Fultz - Charles Holden Elementary
- Aspects of Individual Human Blood Pressure by Ora Newman - Fulton Elementary School
- Reliability Of Your Visual Sense by William M. Gordon - Parkman Elementary School
- How Air Moves In and Out of the Lung by Dorothy Anthony - Luella Elementary
- The Senses: Hearing and Sight by Vincent McEnerney - Peck Elementary
- The Investigation Of The Taste Buds by Ola Jean McGehee - Yale Elementary
- How the Body's Immune System Responds to a Virus by Margaret Mikel - Robert Fulton Elementary School
- The Female Reproductive Organs by Glenda Faye Rowe - John P. Altgeld
- The Sense Of Touch by Louise R. Wooten - Henry Clay Elementary
- The Tongue...A Sense of Taste by Dores H. Cook - Myra Bradwell School
- What is blood and how it circulates in and out of the heart by Merry Jelks - A.C. Powell Elementary School
- Skeletal System And External Body Development Of A Full Term Fetus by Joi Lewis

- The Adverse Effects of Birth Control on the Female Anatomy by Deneen Signator - D.S. Wentworth
- The Brain Reflex System And How It Works by Bobbitt, Ruby - Chalmers Elementary School
- Using Your Senses by Daniels, Elizabeth A. - Collins High School
- The Human Ear by Kall, Maureen
- How Do Toxins Affect the Human Body? by Hale, Patricia - Nansen Elementary School
- Cardiorespiratory Fitness by O'Malley, Paul - Senn Metro Academy
- What's Covering You? and Why? by Weathersby, Dorothy - Sherwood School
- To Have Or Not To Have Oxygen (Part I - Fermentation) by West, Anna - DuSable High School
- The Bone Connection by Artis, Emma - Emmet School
- Nutrition by Gilmore, Marie - Raster School
- Genetic Variations in Hand Span Size by Richard Chilton - Chicago Vocational High School
- Comparison of Respired Air Volume by Matthew F. Mendyk - Steinmetz High School
- The Eye and Color Images by Lacy Grigsby - Paul Robeson High School

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Zoology

- Embryology: From Egg To Chick by Ben Butler Jr. - Laura Ward
- Be A "Peder-Reader" - A Discovery Activity by Lilla E. Green - Hartigan Community Arts Specialty
- Cool Coral Reefs by Frana L. Allen - Skinner School
- Sea Activities by Pedro Rodriguez - Bateman School
- Animals: Here and Now by Marvin W. Bragg - John Hope Community Academy
- Insect Classification by Mushtaq Ali Khawaja - Bateman
- Bernoulli's Principle and Winged Flight by Ben Stark - Illinois Institute of Technology
- Teeth Identification in Omnivores, Herbivores and Carnivores by Allen Nelson - John P. Altgeld
- Insects: Grasshoppers by Wanda Williamson-Johnson - Crown Community Academy
- Insect Inquiries by Allen Nelson - John P. Altgeld
- Wonderful Worms by Judith Lessin - Rogers Elementary School
- Know Your Cousins - Monotremas, Marsupials, and Placentals by Wilma Haynes - Ruggles School
- A Fish Tale by Frances A. Henry - John Whistler School

- Bird Beaks by Katherine Hill - Helen J. McCorkle
- Sharks by Myrtie Bryan - Martha Ruggles
- Dinosaurs---Read All About Them! by Roberta Fried - Douglass Math and Science Academy
- Making Your Dog Your Best Friend by Patricia Guthrie - May Community Academy
- Testing Fats in Food by Patricia A. Banks - Rosa L. Parks Middle School
- Toothpick Worms by Judy Hobson - TAMS
- The Earthworm by Carolyn Matthews - Curie High School
- The Amazing Starfish by Doris Agbefe - South Shore Community Academy High School
- A Guinea Pig Makes An Excellent Classroom Pet by Curtis Brasfield - Horace Mann
- Animal Behavior: "Groggy Goldfish" by Pearlie M. Hayes - Henry Clay Elementary
- What Can You Learn From A Mealworm? by Jessie Rucker - Curie High School
- Animal Life Histories Derived From Morphology by Charles Buzek - Spry Elementary School
- Marine Life: Whales by Myrtle Guice - Powell Elementary School
- Marine Life: Anatomy of a Humpback by Carolyn Hawkins - Adam Clayton Powell Elementary School
- Classification of an Echinoderm by Dill, Henry - Kennedy High School
- But, Why SEX? by McVeigh, Steve - Dunbar VHS
- Owl Pellets by Robles, M. Elena - Kenwood Academy
- Animals and Their Coverings by Sorenson, Beverly - Darwin School
- Animal Behavior by Turner, Homer D. - Hubbard High School
- Classification of an invertebrate:Sponge by Giles, Carol - Collins High School
- The Acetate Animal Hunt by Carter, Linda - DuSable High School
- Reconstructing A Fossil Pterosaur by Elder, Nathan R. - Farragut Career Academy
- How and Why Chameleons Change Colors by Ross, Shirley - Neil School

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Botany

- Let It Grow by Virginia T. O'Brien - Higgins Community Academy
- Which Sex is it? by Pamela Moy - Morgan Park High School
- Fun Activities Using Seeds by Imara Abdullah - Douglas Academy
- Data-gathering Activities Relating to Trees in Their Environment by Charles Buzek - John Spry School

- Investigating the Structure of the Flower by Charles Buzek - John Spry School
- Transportation in Plants by Matthew Gibson - Joliet West High School
- Structure Of A Plant by Sheila Mckinnon - Sherman School
- Structure of Seeds and Effects of Fertilizer on Plant Growth by Ben Stark - Illinois Institute of Technology
- A Close Encounter of the Tree Kind by Charles T. Buzek - Spry School
- Aztec Floating Gardens by Vanessa Villalobos - Oscar Mayer Elementary
- How Plants Spice Up Our Lives by Trudy S. Moore - Scott Joplin Elementary School
- Plant Actions by Angelica Wright - Robert Fulton
- How Buds on Trees Survive the Cold (and Related Mysteries) by Ben Stark - Illinois Institute of Technology
- Structure and Function of Seeds by Ben Stark - Illinois Institute of Technology
- Seed Germination by Calvin Harris - Bethune Elementary
- The Structure of A Flower by Dorothy J. Brandon - Anton Dvorak Elem. School
- Birth of a Plant From a Seed by Janet A. Elkins - Douglass Middle S & M Academy
- Indoor Gardening by Patricia H. Haynes - Wirth Elementary School
- Photosynthesis by Karen F. Adams - Burnside Scholastic Academy
- Tree Identification by the Use of Leaves by Elaine E. Messal - Henry Clay Elementary
- Seeds-Seed Sort by Anna Summers - Henry Clay Elementary School
- Algae--Where does it Live? by Mary Ellen Dote - St. Cletus School
- What are Some Substances That Will Cause Algae To Grow? by Liz Jones - Yale School Elementary
- The Parts of A Perfect Flower by Guinevere Miller - Englewood High School
- Photosynthesis: A Controlled Experiment by Coley, Juana - Rosa Parks Middle School
- Four Parts of a Green Plant and the Functions of each Part by Hawthorne, Sarah F. - Coles Elem. School
- The Effects of Light & Temperature on the Growth & Development of Plants by Robinson, Minnie - Fenger High School
- From Flower to Fruit by Ward, Joy A. - Hope Community Academy
- Growth of Plants and Bacteria by Chaffin, Mildred C. - Hyde Park Career Acad.HS.
- Showing Nature's Way-Plant Development & the Plant Parts We Eat by Ewers, Katherine - Burke Elementary School
- Germination: Name That Seed by Blonzella Campbell - Chicago Vocational High School

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Microbiology

- Cell Structure and Function by Barbara J. Baker - Doolittle West Primary School
- Mold Investigations by Ben Stark - Illinois Institute of Technology
- Micro-organisms by Janet Elkins - F.A. Douglass Middle Math & Science Academy
- Micro-organisms by Janet Elkins - F.A. Douglass Middle Math & Science Academy
- Cell Division and Mitosis by Nicholas DiGiovanni - Naperville Central High School
- Cell Size and Division or How Big Would You Want To Be by Nicholas DiGiovanni - Naperville Central High School
- The Effects Of Osmotic Balance And Imbalance In Living Cells by Wayne Brown - Collins High School
- Cells, The Structural and Functional Units of Life by Carollyn V. Warlick - South Shore High School
- A Hands-On Approach to Teaching the DNA Structure and FUNCTION by Carter, Linda - DuSable High School
- Plant and Animal Cells by Will White - Copernicus School

Genetics

- People Are Like Peas in a Pod by Eartha Sherrill - Daniel Hale Williams School
- DNA Extraction with Kitchen Chemistry by Donna M. Bronson - John B. Drake
- Monstrous Mutations by Pamela S. Moy - Morgan Park High School
- DNA/Genetics by Sandra E. Broomes - William T. Sherman School
- Groovy DNA Beads by Celestine M. Jeffreys - Hales Franciscan High School
- Wearing My Genes: Basic Principles of Heredity by Anita Jacobs - Horace Mann
- Inheritance in Maize (Indian Corn) by Renee Allen - Louis Wirth Experimental
- Traits by Jennifer Wesley - Scammon Elementary School
- Principles of Heredity by Williamson, Morris - Esmond School
- Beans and Genes/Genetic Probability by Joyce Craft - Hyde Park Academy

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Environmental Studies & Ecology

- Saving Humpty Dumpty by Christine Etapa - Gunsaulus Scholastic Academy
- Life in a Drop of Water by Marva L. Anyanwu - Wendell E. Green
- Topics in Environmental Science by Willie Hoskins - Williams School
- How Pollution Disrupts Our Natural Environment by Sheila Mckinnon - Sherman Elementary School
- Recycling by Shirley A. Knight - John Whistler Elementary
- Building A Biome by Kelly Ludwig - Lincoln-Way High School
- Zebra Mussels and Water Pollution by Allen Nelson - John P. Altgeld School
- Soil Examination by Allen Nelson - John P. Altgeld Elementary School
- Food Webs by Kelly Ludwig - Lincoln-Way High School
- The Effect of Automobile Exhaust on Hydra in an Environmental Chamber by Donald H. Anderson - Foreman High School
- The Effects of Trash and Garbage On the Environment by Bernadette M. Gilbert - Charles Kozminski Community Academy
- Population Study and Applications Using PTC Paper by Susan H. Smigla - Leslie Lewis Elementary
- Biological Communities by Jimmie Whitney - Lucy Flower Vocational High School
- The Effects of Pesticides on the Food Chain by Betty Conley - Byrd Academy
- The Properties of Air by Dores H. Cook - Gallistel Language Academy
- How Organisms Respond To Changes In Their Environment by Carmella Gordon - Farragut High School
- Recycling by Brad Wohlgemuth - Thornton Twp. H.S.
- Urban Effects On Inshore Plankton by Arnam, Steve - Roosevelt H.S.
- Acid Rain And How It Affects Our Environment by Iftner, George - Schools, various
- Filtering Water To Prevent Pollution by Ander, Perry - Robeson High
- Living Organisms As Indicators of Pollutants In Fresh Water Ecosystems by Hubers, Hendriekje - Chicago High School for Agricultural Sciences
- Air Pollution by Levine, Stephen - Gordon Upper Grade Center
- Water Purification by Wilson, Wardell - Raster School

Biochemistry

- Photosynthesis, Respiration, and the ATP-ADP Cycle by Clovis O. Price Jr. - Lucy Flower High School

- What's the Matter? by Earline Muhammad - Louis Wirth Academy of International Studies
- What's the Matter? by Earline Muhammad - Louis Wirth Academy of International Studies
- The Chemistry of Water by Virginia Harris - DuSable High School
- Chromosome Karyotyping by Gray, JoAnne S. - George Henry Corliss High School
- The Role of Enzymes by Rucker, Jessie B. - Curie Metro High School
- The Coding of Protein Molecules By D.N.A. by Glenn, Georgia S. - Bogan High School
- Natural and Synthetic Fiber by Grant, Erskine - Washington High School
- Molecular Shuffle by Johnson, Betty - Haugan Elementary School
- Constructing A Dichotomous Key by Margaret Bankhead - Robert A. Black Magnet School
- Active Transport Across The Plasma Membrane by Dorothy Sarmiento - Lindbloom Technical High School

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General Biology

- Food Chain by Lyvonia G. Hearns who is Retired and feeling Wonderful!
- Memory and Learning by Mary A. Mason - Clay Elementary School
- Cells Are Us by Cheryl L. Trammell - Delano Elementary School
- Enquirer-type Newspapers Have Many Uses by Russ Osantowski - Carter Elementary
- Living and Non-Living by Ollie L. Jamison - Delano Elementary School
- Freshwater Sharks Bite Children at 35th Beach. A Play by Russ Osantowski - Carter Elementary
- Food For Energy - Four Food Groups by Anna M. Rembert - Faraday Elementary School
- Classification by Bobbie Dixon Heard - McCorkle Elementary School
- A Biology Game To Promote Classification And Observation by Charles T. Buzek - Spry School
- Introduction to the Scientific Method by Maureen P. Kall - Hillcrest H.S.
- A Demonstration of Photo-and Geotaxes in nauplii of *Artemia salina* by Daniel C. Koblick - Illinois Institute of Technology
- Nutrition by Donna Lynn Attinello - Gallistel Language Academy
- Biology Trivia Questions by Carol Giles - Collins High School
- Biology Trivia by Carol Giles - Collins High School
- The Characteristics of Living Things by Mary Hopkins - Edward Coles School
- Watercycle by Clara Phillips - Dawes Elementary

- Diffusion by Charles, Harold - Farragut Career Academy
- Biology Trivia by Giles, Carol - Collins High School
- Nutrition Awareness by Cora, Luis - Lake View High School
- Observations (collecting data) by English, James - Simeon H.S.
- Diffusion by Gupta, Raj - Schurz High School
- Problem Solving: Dots, Symbols, Words, and Proteins by Sims, MaryLouise - Farragut Career Academy

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Miscellaneous

- Clouds - Movement and Type by Tanisha Guterz-Kwaaning - John Farren
- Natural Cleaners by Jeannine Frazier - Farren Fine Arts
- Rock Formation by Therese Donatello - St. Edward School
- Land Formations by Barbara J. Baker - Doolittle West
- Oceans AWAY by Frana L. Allen - M. T. Elementary School
- Somethin' Sweet by Angela Patrick - Crown Academy
- Can Young Children Distinguish Between Living and Non-living Things? by Joyce E. Combest - Daniel Dale Williams School
- Stacking The Deck on Nutrition by Elaine Pauline Agusto-Laster - Daniel Hale Williams Elementary School
- Calorie Connection by Imara Abdullah - Douglas Community Academy
- Biological Flight by Russell C. Osantowski - Bateman Elementary
- A Taste of Our Classroom by Carisa R. Bryant - W. K. Sullivan Specialty Elementary School
- Usefulness of Irrigation by Gloria T. Bond - Coles School
- Water Conditions by Kelly Ludwig - Lincoln-Way High School
- Measuring Matter by Jessie D. Barnes - Henry Clay Elementary School
- Dinosaur Tracks and Critical Thinking by Charles T. Buzek - Spry School
- Discover Science by Claire Davis - Myra T. Bradwell Elem.
- Data Sampling by Debra Dortch - Henry Suder Elementary
- Physical And Chemical Change Of Six White Substances by Jacqueline Sanders - Myra Bradwell School
- How Big Is Big? by Lucille Smith - Horace Mann Elementary School
- Extra Sensory Perception by Heflin, Marie - Walter Dyett M.S.

- For Safety's Sake: Introduction to Laboratory Safety in Science by Gaddis, Linda - Walter H. Dyett
- The Frigid Gourmet by Drolson, Rochelle - Clemente High School
- GenEng by English, Jami - Dyett Middle School
- Paper Chromatography - Chemical and Mechanical by Valerie Young - Kenwood Academy

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Smog and Your Health

The Issue

Smog can cause damage to your heart and lungs - even when you can't see or smell it in the air around you.

Background

When we hear the word smog, many of us picture the chemical "soup" that often appears as a brownish-yellow haze over cities. But smog isn't always visible. It's a mixture of air pollutants, including gases and particles that are too small to see. Smog often begins in big cities, but smog levels can be just as high or higher in rural and suburban areas.

We all need to protect our health against potential damage from smog.

Types and Sources of Air Pollution

The scientists who study smog are most concerned about the following types of air pollution:

Type:	Particulate Matter - or PM. This is the name given to microscopic particles that pollute the air. They vary in size and chemical make-up.
Sources:	Industrial and vehicle emissions, road dust, agriculture, construction and wood burning.
Type:	Ground-level Ozone. This gas is the result of a chemical reaction when certain pollutants are combined in the presence of sunlight. Ground-level ozone shouldn't be confused with the ozone layer in the sky, which protects us from ultraviolet radiation.
Sources:	Ground-level ozone comes mostly from burning fossil fuels for transportation and industry. Ozone levels peak between noon and 6 p.m. during the summer months.

- Smog
- Ultraviolet Radiation
- Vermiculite Insulation Containing Asbestos
- Wood Smoke
- Food
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There is also concern about:

Type:	Sulphur dioxide
Sources:	Coal-fired power plants and non-iron ore smelters

Type:	Carbon monoxide
Sources:	Mostly from burning carbon fuels (e.g. motor vehicle exhaust)

Potential Health Effects

Since smog is a mixture of air pollutants, its impact on your health will depend on a number of things, including:

- The levels and types of pollutants in the air
- Your age and general state of health
- The influence of weather
- How long you are exposed
- Where you live

Smog can irritate your eyes, nose and throat. Or it can worsen existing heart and lung problems. In exceptional cases it may result in an early death.

The people most at risk are those who suffer from heart and lung problems. Many of these problems are more common in seniors, making them more likely to experience the negative effects of air pollution. Children can be more sensitive to the effects of air pollution because their respiratory systems are still developing and they tend to have an active lifestyle. Even healthy young adults breathe less well on days when the air is heavily polluted.

The health effects of ground-level ozone and particulate matter (PM) is also cause for concern. Some studies suggest that long-term regular exposure to PM can increase your risk of early death and perhaps lung cancer. Studies on ozone show that once it gets into your lungs, it can continue to cause damage even when you feel fine. This is why the federal government, including Health Canada, is working to reduce the risks to your health.

Areas of particular concern for ozone in Canada are:

- The Windsor-Quebec City corridor (Ontario and Quebec)
- The Lower Fraser Valley (British Columbia)
- The Southern Atlantic region

Minimize Your Risk

To reduce your exposure to smog and its potential health effects:

- Check the Air Quality index in your community, especially during "smog season" from April to September. Tailor your activities accordingly.
- Avoid or reduce strenuous outdoor activities when smog levels are high,

especially during the afternoon when ground-level ozone reaches its peak. Choose indoor activities instead.
- Avoid or reduce exercising near areas of heavy traffic, especially during rush hour.
- If you have a heart or lung condition, talk to your health care professional about additional ways to protect your health when smog levels are high.

To help reduce the overall levels of smog in the air:

- When possible, use public transportation instead of your car. You could also walk or ride your bicycle, as long as smog levels are not too high.
- Look for alternatives to gas-powered machines and vehicles. Try a rowboat or sailboat instead of a motorboat or a push-type lawnmower instead of one that runs on gasoline.
- Consider fuel efficiency when you buy a vehicle. Keep all vehicles well maintained.
- Reduce energy use in your home. Learn more about alternative energy resources.
- Do not burn leaves, branches or other yard wastes.
- Consider joining a citizens' committee to advocate for cleaner air in your community.
- Spend time talking with your children about the importance of a sustainable lifestyle.

Health Canada's Role

Health Canada's research on the health effects of smog played a role in the development of Canada-Wide Standards for particulate matter and ground-level ozone. Adopted in June 2000, these standards are an important step in reducing the effects of smog on our health.

Health Canada will continue to study the effects of short and long-term exposure to smog-producing pollutants. These studies will lead to more standards and guidelines to help protect Canadians against the effects of smog.

Need More Info?

For further information contact:

Air Health Effects
Safe Environments Programme
275 Slater, PL3807B
Ottawa, Ontario
K1A 0K9

Or visit:

Health Canada's Air Quality Division

Health Canada's Climate Change and Health Office

It's Your Health - Dioxins and Furons

Or visit Environment Canada's Air Quality Web site
Tel: 819-997-2800 or 1-800-668-6767

Additional *It's Your Health* articles
You can also call (613) 957-2991

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- Also available in PDF Version

Last Updated: 2004-02-06 Important Notices

Activity: What's "Riding the Wind" in Your Community?

Ever wonder what's floating in the air? Did you know that wind-blown particles, we can easily, see range in size from approximately 20 to 100 microns. To give you an idea of just how large these particles are, a human hair is approximately 70 microns in diameter. Since the movement of these wind-blown particles is more horizontal than vertical, it might surprise you that a good collecting surface is a vertical plane. Sticky paper wrapped around a jar can be used as a sample collector and will work well to capture the particles. By making your own sample collector you will discover what actually floats in our air, determine what the sources of these particles might be, and learn which direction the particles come from.

Subjects: Science, Mathematics

Grade Level: 5-8

Time: 1 class period to set up, 1 class period to analyze sample collection should take about 1-week

OBJECTIVES

As a result of participating in this activity, you will be able to:

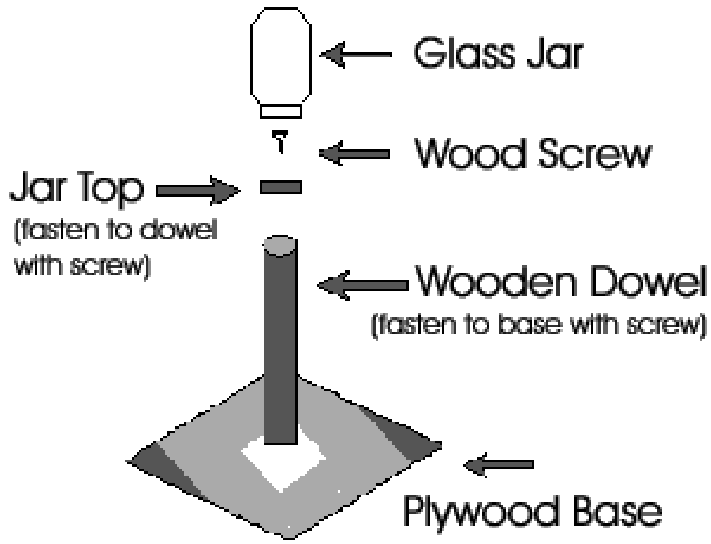
1. determine a measure of the number of larger particles in the air which are carried on the wind,

2. determine the approximate direction these particles are coming from, and

3. consider sources of particles sampled during this activity.

MATERIALS

- Small glass or plastic jar with a lid. Several jars that fit the same lid will allow for the collection of several samples.
- Plywood base (approximately 24" x 24")
- Wooden dowel (approximately 3" diameter, 30" long)
- 2 Wood screws
- Compass
- Spray can of quick drying clear lacquer.
- Double sided tape, or contact paper.

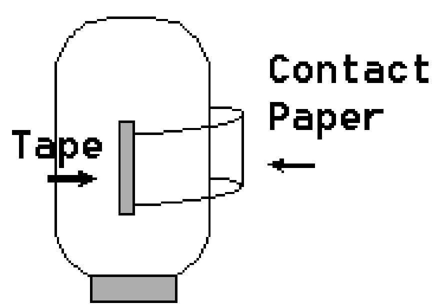


PROCEDURE

1. Assemble the sample collection stand as indicated in the picture to the right.

2. Place the stand for holding the glass jar, on a flat and safe area of the school grounds or roof. Try to keep the sampler as far away from obstructions as possible.

3. Wrap one strip of double sided tape around the jar. If using contact paper be sure that the sticky side is facing away from the jar. Fasten one edge to the jar with tape and be sure that the edges overlap and stick together so that the paper will stay on the jar. Mark the exposed edge as North.



4. Screw the jar onto the cap on the stand and use a compass to be sure that the edge marked "North" is facing North.

5. Leave the jar exposed for seven days. Then spray the paper with the lacquer to fix the particles collected and to avoid having additional particles adhere to the paper.

6. After the lacquer dries, remove the tape or contact paper from the sampler and

divide it into eight equal parts. One section of the strip will represent each direction i.e., North, Northeast, East, etc. Label each section.

7. Lay the tape on the table and estimate the percent of particle coverage for each section. Use the table below to record your estimates.

Direction	N	NW	W	SW	S	SE	E	NE
Estimated Coverage								

8. Graph the data from your table using the blank graph on the next page. For the purpose of your graph, 2 cm = 10% coverage. Your sample site will be at the center of the graph. For an example of how to interpret your data, review the attached sample data table and graph.

9. When your graph is finished, you should be able to look at it and start to form simplified ideas regarding from what general direction particulate matter, and possibly other pollutants that affect your community, come.

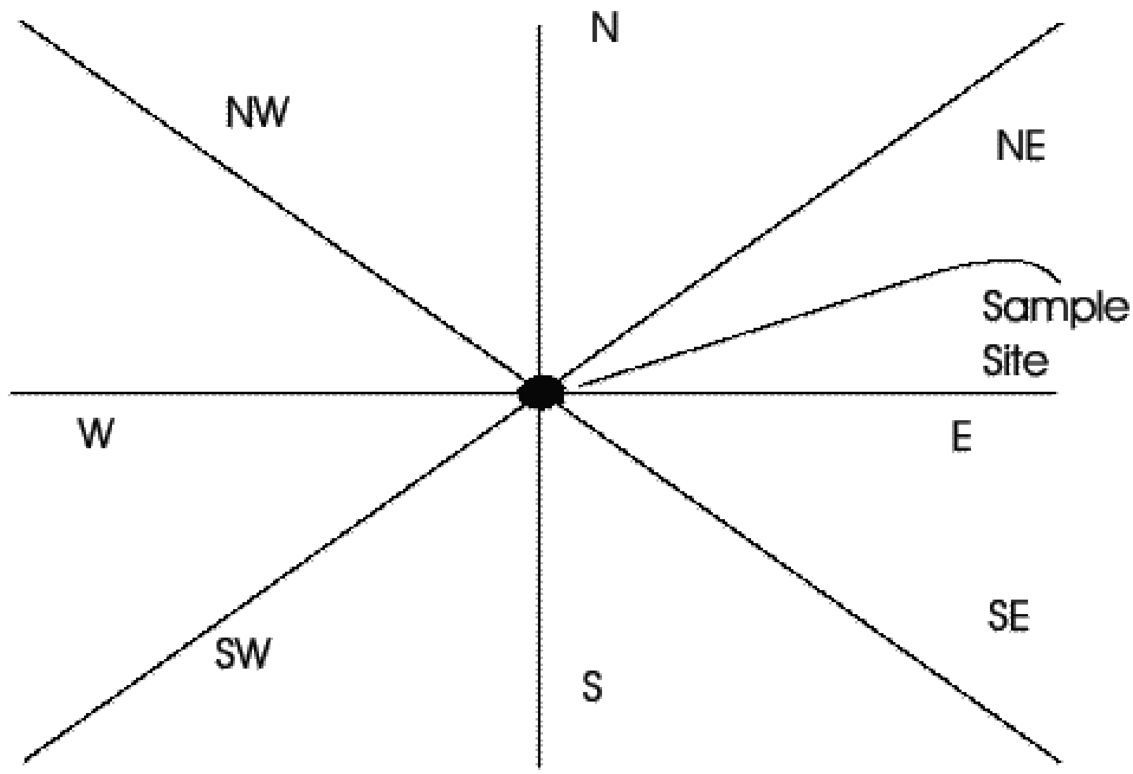
After finishing your graphs, be prepared to discuss the following:

1. From what direction did most of the particulate matter appear to come?

2. What do you think the source of the material is?

Possible answers: Nearby dirt driveway, farm activity, metropolitan area, etc.

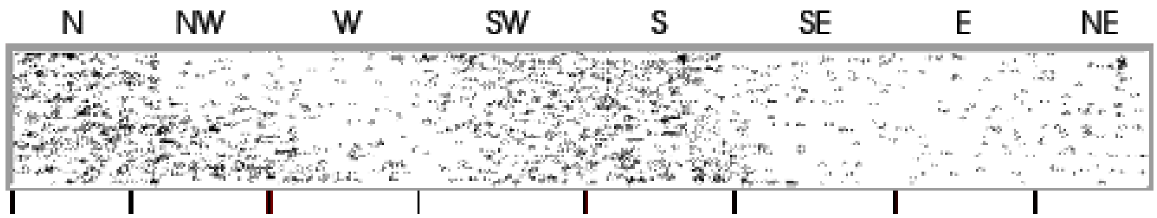
What's "Riding the Wind" in Your Community?



Data Collection Site ______________________

Data Collection Dates ______________________

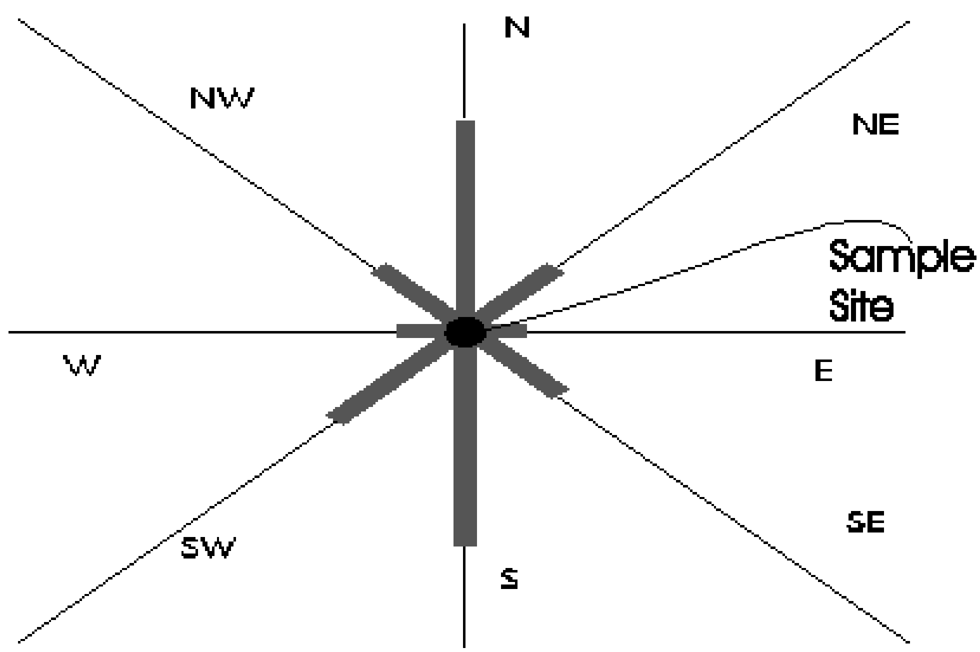
Sample Data Table & Graph



For example we estimate the strip above is covered as indicated in the table below.

Direction	N	NW	W	SW	S	SE	E	NE
Estimated Coverage	25%	10%	5%	15%	25%	10%	5%	5%

Start with the estimated particle coverage that came from the north, 25%. Since 2 cm on the graph represents 10% coverage, a 5 cm line will represent 25%. Draw a bar north extending 5 cm from the center of your graph. A 2 cm bar should extend towards the northwest, and so on.



Adapted from Air Pollution Control Association, *Air Pollution Experiments for Junior and Senior High School Science Classes*. Pittsburgh, PA, 1972

THE LUNG ASSOCIATION
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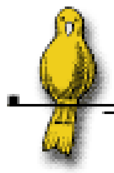

Workplace

The building you work in is another indoor environment that can have air quality problems. Indoor air quality (IAQ) at the office or workplace is subject to much of the same IAQ problems at home. Building materials, carpets, cleaning products, tobacco smoke and ventilation share the same IAQ challenges as the home. However, some IAQ problems such as scents and fragrances, automobile exhaust, cleaning solvents, and manufacturing activities can be more common at the workplace.

Why should you care about IAQ at work?

As an employee, your health may be at risk from poor IAQ at work. Poor IAQ can exacerbate allergies and asthma, cause eye, nose and throat irritation, or can result in fatigue, nausea or illness. The health effects of these symptoms can lead to poor work performance and productivity, as well as your own well being. In the long-term, these symptoms could also lead to sickness, missed work and loss of income.

As an employer, it's your responsibility to ensure a safe and healthy work environment. Poor IAQ can impact the health of your employees and result in increased absenteeism, reduced productivity, and potential safety hazards. Increased health claims from IAQ related impacts or illnesses can be avoided. Talk to your employees today about their air quality concerns. The table below list some examples of IAQ problems in the workplace.

In the Office

FAIRE Début

- Pressed-wood office furniture and carpet can be a source of formaldehyde
- Poor ventilation can exacerbate asthma and allergies
- Exposure to tobacco smoke is a proven health risk for everyone and can be a serious health threat to employees with asthma
- Personal care and cleaning products often contain many volatile organic compounds (VOC's) and chemical compounds

At the factory

- Open doors around the loading dock allows engine emissions inside the workplace
- Emissions from gas and propane forklifts can cause nausea, fatigue and illness
- Manufacturing often requires chemicals and solvents in the production process
- Cleaning products used for some industrial activities can be quite harsh or toxic

The good news is that you can do something right now to improve the IAQ at your workplace. To learn more, please download our Indoor Air Pollution in the Office (PDF).

Educational Resources in Social Studies

Curricular Resources **(Information/explanations for students and teachers wishing to learn more about Social Studies)**			
Canadian Studies • British Columbia • Canadian Geography • Canadian History • Canadian Law	Environment	History	Other Social Studies
Instructional Materials **(Lesson plans and teaching tips/ideas for Social Studies teachers)**			
Canadian Studies	Environment	History	Other Social Studies
Theme Pages **(Curricular resources as well as Instructional Materials on specific Socials Studies topics)**			
Air Quality			
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Biomes • Antarctic Theme Page • Arctic Theme Page • Drylands/Deserts • Temperate Forests • Tropical Rainforests • Tundra • Wetlands			
Canadian Military History			
Celebrating Women			
Clocks and Calendars			
Countries			
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Hazardous Wastes Disposal
Holocaust
Hunger
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Renaissance
Sustainable Development
Water Quality

Previous Screen

Weather

01/09/2004 - Updated 02:52 PM ET

Understanding Clouds and fog

Clouds are usually the most obvious feature of the sky. They both reflect weather patterns and play a role in what the weather does. The links below take you to a great deal of information about clouds.

Locations of clouds

- Low-level clouds: (generally found below 6,500 feet, or 2,000 meters) Low-level clouds are usually composed of liquid water droplets, but they can have snow and ice crystals in cold weather
- Mid-level clouds: (generally found between 6,500 and 23,000 feet, or 2,000 and 7,000 meters) Most mid-level clouds are composed of liquid water droplets during summer and a liquid droplet-ice crystal mix during winter. Mid-level cloud names are preceded by an "alto" prefix.
- High-level clouds: (generally found above 20,000 feet, or 6,000 meters) High-level clouds are composed of ice crystals and tend to be very thin and wispy. High-level cloud names are preceded by a "cirro" index

Today's Top Weather Stories

" Illegal immigrants avoid Charley relief - 1:34 PM
" Tropical Storm Gaston hits South Carolina - 1:15 PM
" Arctic Ocean both cools and warms Barrow, Alaska - 1:49 PM
" Arctic expedition seeks ancient climate record - 3:26 PM
" Tampa radar failed before Hurricane Charley hit - 8:32 AM
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Names represent different kinds of clouds

- Stratus clouds are a uniform gray and usually cover most of the sky.
- Cirrus clouds are thin and high in the sky.
- Cumulus clouds are lumpy and can stretch high into the sky.
- Thunderstorms are cumulus clouds, sometimes called "thunderheads."
- Mammatus clouds have pouches that hang down.

More about different types of clouds

- Australian Severe Weather: Photos of clouds
- Plymouth State College: Cloud Boutique.
- NASA: On-line cloud chart with many photos

People and clouds

- Conspiracy theories find menace in contrails.
- Understanding cloud seeding.

Different kinds of fog, where fog forms

- Fog, how to forecast when it's possible
- Advection fog forms when humid air flows over cold ground or water.
- Radiation fog forms on generally clear, cool nights.
- Steam fog forms over water, often in the fall.

- [Overnight rain] can enhance fog that forms in the morning.
- **Precipitation fog** forms when rain or snow falls.. As precipitation falls into drier air below the cloud, the liquid drops or ice crystals evaporate or sublimate directly into water vapor. The water vapor increases the moisture content of the air while cooling the air. This often saturates the air below the cloud and allows fog to form.
- **Upslope fog** is very common along large hills and mountains. It forms when winds blow up the side of a hill or mountain, which cools the air.
- **Valley fog** forms in mountain valleys during winter and can be more than 1,500 feet thick. Often, the winter sun is not strong enough to evaporate the fog during the day. When the air cools again the following night, the fog often becomes thicker, which makes it even harder for the sun to burn it off the following day. These fogs can last for several days until strong winds blow the moist air out of the valley. The tendency for cool, dense air to pool at the bottom of valleys also enhances valley fog.
- Pop-up map: Yearly average days with fog in the USA

AP

A ferry motors through steam fog as it passes House Island in Casco Bay on its way to Portland, Maine, where the temperature dropped to minus-8 on Jan. 9, 2004.

Clouds and the atmosphere, the water cycle

- Why cloudy nights tend to be warmer.
- Understanding water in the atmosphere.
- Dust can stifle rain formation in clouds.
- Weatherwise: How much clouds weigh
- How the Weatherworks: Sky Awareness Week.
- U. of Ill.: Clouds and precipitation
- USGS: Clouds are part of the water cycle.

Questions and answers about clouds

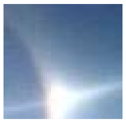
- Help on identifying an unusual cloud
- Answers archive: Clouds, fog, rain, snow, drizzle

Clouds and climate change

- NASA: Clouds and climate change.
- NOAA: Clouds and climate.

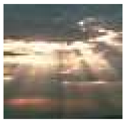
Learn more about the sky and space

Learn about the sky, space



- Resources: Astronomy and space
- Resources: Sky colors and phenomena
- Resources: Clouds
- Resources: Auroras
- Resources: The sun and space weather
- Sun and moon, rise and set times, time zones

Photo gallery, graphics



- Sky watching photo gallery
- Understanding the moon's phases
- Earth's tilt creates the seasons

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The Cloud Case: TEACHER'S GUIDE

The Cloud Case is an interactive online lesson about how clouds form through the principles of condensation and evaporation. The lesson is written around an experiment that the student can perform, or can watch being performed, that will illustrate the ideas of the lesson.

Grade Level:

This lesson has been designed for grades 5 - 8.
It is designed to take 30 minutes to read through and complete. Performing the experiment will take longer.

Overview:

This lesson teaches how clouds form and how air pressure and air temperature affect their formation. The lesson is delivered in the story of Mike Breezy, Air Detective, who tries to solve the "The Cloud Case". His friend, Professor Less, gives both Mike and the students the facts about clouds. An experiment follows the story that gives students the chance to see the principles demonstrated they have just read about. Finally, there is a simple quiz to give students a chance to review what they have learned.

The Experiment:
The purpose of the experiment is to demonstrate the role temperature plays in cloud formation. A sample atmosphere is created using a plastic bottle filled with water. By squeezing the bottle, you can change the temperature of the air inside. When the air temperature is decreased, a cloud is created inside the bottle.

NOTE: This experiment should be performed under adult supervision because it involves the handling of matches.

Materials:
a large clear plastic bottle with cap
a measuring cup
cold and hot water
matches

Procedure
#1: Pour 1/3 cup of cold tap water into a clear plastic bottle and place cap on it. Shake the bottle for 30 seconds and then set it on your table.

#2: Squeeze the bottle and then release the pressure. Repeat this process several times.

In this step you are saturating the atmosphere inside the bottle. By squeezing the bottle, you increase the air pressure inside the bottle, which increases the air temperature. With the air heated, more water moves into the air, saturating it. When you release the pressure on the bottle, you decrease the air pressure. This lowers the air temperature and causes condensation in the bottle. These are the principles that will allow you to create a cloud in the next step.

#3: Remove the cap from the bottle and light a match. Hold the match over the mouth of the bottle. Quickly squeeze the bottle to extinguish the match; then slowly release the pressure to draw smoke into the bottle. Replace and tighten the cap. Repeat Step #2.

In this step, a cloud should have formed above the water inside the bottle. As in Step #2, squeezing the bottle forced condensation inside the bottle. Now that you have added smoke into the bottle, the water has something to condense upon. The condensed water forms the small cloud inside the bottle.

#4: Rinse the bottle thoroughly and pour 1/3 cup of hot tap water into it. Shake the bottle for 30 seconds and place it on your table.

#5: Squeeze the bottle and then release the pressure. Repeat this process several times. Then repeat Step #3, extinguishing a match over the mouth of the bottle and drawing the smoke inside. Then repeat Step #2 again, squeezing and releasing the bottle to create a cloud.

In this step, a bigger cloud should form in the bottle. This is because of the hot water has heated the atmosphere inside the bottle, so it is able to hold more water than before. So when condensation is forced inside the bottle, more water condenses and a larger cloud forms.

The Quiz:
At the end of the Cloud Case is an online quiz that students can take, with questions about facts covered in the Cloud Case. The quiz is graded online and results are sent by e-mail to their teacher.

Lesson Objectives:

To teach students about condensation and evaporation.
To have them involved in an experiment that will reinforce what they learn about condensation & evaporation.

Read through the Case

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Topic: Cloud Formation

Grade Level: Fourth

Concept: Cloud formation results when warm, humid air rises and cools, causing the water vapor in the air to condense and form clouds.

Teacher Materials:

--a large jar

--a plastic bag of ice that will fit over the jar opening

--a pitcher of warm water

--1 sheet of black paper

--flashlight

--matches

Student Materials:

--pen and paper to record observations

Optional Extension Student Materials:

--more jars, bags of ice, black paper, flashlights, and warm water

--collected dust

--flour

--sand

--cedar shavings

--any other particulate materials

--white construction paper

--newspaper

--crayons

Teacher Background Information:

Sunlight causes water to evaporate into the atmosphere. This air containing the water vapor is heated at the surface of the earth and rises. As it rises, it cools and the water vapor condenses on some form of particulate matter such as dust, ash, or smoke to form clouds.

Management Strategies:

This activity would be most appropriately done with small groups so that all students can view the cloud formation in the jar. Other class members could be working on researching the different types of clouds, drawing and labeling these clouds, researching and drawing the water cycle, working on a forecast for the rest of the day based on the clouds in the sky, etc. The activity itself should not take more than 10 to 15 minutes. For safety reasons, students should not be allowed to handle the matches. Also, students need to be careful around the glass jars. Much of the following procedure will vary, depending on students' reactions, comments, and levels of understanding.

Procedure:

1. Ask students what some of the different types of clouds are, what they are made of, and ask the focus question, how do you think clouds form? The responses to this question could be written on the board to return to later.

2. Tell the students that we are going to perform a simulation of the forming of a cloud. Take out the jar and have one of the students tape the black piece of paper onto one side of the jar. Ask another student to pour the warm water into the jar until it is one third full.

3. Light a match and hold it in the jar for a few seconds and then drop it in. At this point, have a student quickly cover the jar with the bag of ice.

4. Have another student (or teacher) shine the flashlight on the jar while they record their observations.

5. Now the students will explore what happened. The following questions can be used to help the class learn about what was happening:

--What did you see in the jar? (a cloud)

--Where did the cloud come from? (the water in the bottom of the jar)

--How did the warm water effect the cloud formation? (caused the water

to evaporate and warmed the air, causing it to rise)

--What did the ice cubes do to help the clouds form? (cooled the air [made

the water vapor condense]).

--What role did the match and its smoke play in the cloud formation?

(gave the water something to condense or grab on to)

--Now what would you tell me a cloud is made of? (small water droplets)

--Ask someone to describe the process of cloud formation from what they

just learned.

Assessment/Evaluation:

As a learning activity in itself, assessment is not really needed, but an option for assessment would be to have students draw a picture of how the cloud formed in the jar. In addition, the products of the following extension activities could be assessed.

Extension/Integration:

As an application of what they learned, each student could draw a picture of how a real cloud would form, and what effects the warm earth and the cool air in the mountains would have. The process could be repeated by students without using the match or with dust, flour, sand, cedar shavings, or other particulate materials to see if the cloud would still form. As an art activity, students could construct different types of clouds by cutting two sheets of construction paper simultaneously and stapling them part of the way together. Then they can be filled with newspaper and decorated.

For a math activity, students could record the clouds they see for a couple of weeks and graph how many days they saw each type of cloud. A language arts activity that could be used is to have students write weather reports and then present them to the class. Students could also write poems about clouds or stories from a cloud's point of view, discussing what type of cloud it is and what kind of weather it would bring.

Source:

Bugenig, D. (1996). *How does a cloud form?* [On-line]. Available: ftp://ftp.unr.edu/pub/archive/mailing-lists/galileo/clouds.

Source for the teacher background information and most of the extension activities was

myself.

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Clouds & Scenics *Page 1*

Dave 'Stormguy' Crowley

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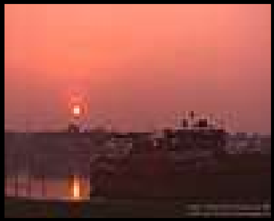
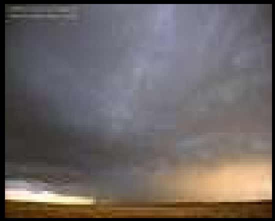





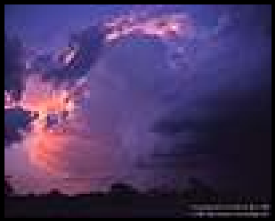








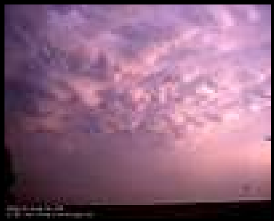




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Clouds, Precipitation
- introduction
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- cloud types
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User Interface
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- text

Graphic by: Yiqi Shao

A cloud is a visible aggregate of tiny water droplets and/or ice crystals suspended in the atmosphere and can exist in a variety of shapes and sizes. Some clouds are accompanied by precipitation; rain, snow, hail, sleet, even freezing rain. The purpose of this module is to introduce a number of cloud classifications, different types of precipitation, and the mechanisms responsible for producing them. The Clouds and Precipitation module has been organized into the following sections:

Sections

Last Update: 07/21/97

Development
The importance of rising motion and the mechanisms responsible for lifting the air.

Cloud Types
High, middle and low-level clouds, vertically developed clouds, plus some less common cloud types.

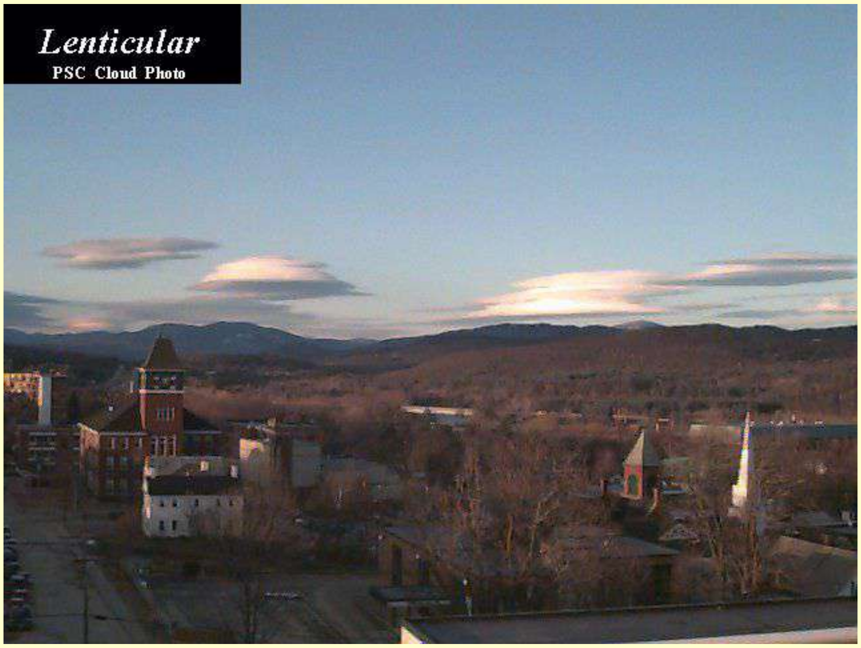
Precipitation
Rain, snow, hail, sleet and freezing rain.

Acknowledgments
Those who contributed to the development of this module.

The navigation menu (left) for this module is called "Clouds, Precipitation" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Advection

Development



Lenticular Clouds over Plymouth, NH

Plymouth State University Meteorology Program Cloud Boutique

The Plymouth State Meteorology Program has developed this server to provide explanations of and access to detailed pictures of some basic cloud forms. The cloud images are relatively large (640x480) in order to show detailed structure and features. All of these pictures were taken in the local area around Plymouth, New Hampshire and most from the weather observation deck on the roof of the Boyd Science Center on the Plymouth State campus. Clouds can move and change shape quickly as indicated in this 30 minute time-lapse mpeg video loop. The purpose of this "boutique" is to provide a general cloud reference and is not intended to provide an all-inclusive list. Images will be added to or changed as opportunities permit.

Cloud Classification

Clouds are generally classified based on characteristics, such as, altitude, appearance, or origin. Altitude distinctions apply to those clouds that fit in various layers of the atmosphere as follows:

- high clouds - have bases above 18,000 feet
- middle clouds - have bases between 7,000 and 18,000 feet
- low clouds - have bases below 7,000 feet
- fog - cloud in contact with the ground
- multi-level clouds... vertically thick spanning multiple layers
- orographic clouds - distinct clouds that form via interaction between wind and mountainous terrain features

In appearance, clouds may be thick or thin, have well defined edges or be very diffuse, appear hairlike, cellular, towering, or in sheets, and be associated with fair weather or precipitation. Most clouds owe their existence to upward vertical motion of air, hence they are often associated with weather producing phenomena, such as fronts, troughs, and low pressure systems. However, topography can also help move air upwards and produce clouds.

Cloud Descriptions and Pictures

This section provides verbal descriptions and pictures of clouds that have been observed in this area. Because of their size, these images have been stored in JPG format. To view a picture, click on the appropriate cloud name or other highlighted text.

High Clouds are primarily composed of ice crystals and include the following:

- Cirrus are high altitude wispy clouds. They are usually quite thin and often have a hairlike or filament type of appearance. The curled up ends as depicted in this picture are very common features.
- Cirrocumulus are high clouds that have a distinct patchy and/or wavelike appearance, such as, in our patchwork cirrocumulus photo, composed of many individual cloud elements, or in our wavy cirrocumulus photo with its banded linear structure. These features are common to all types of cumuloform clouds.
- Cirrostratus are high clouds that usually blanket the sky in ill-defined sheets. These clouds are usually optically thin and the sun and moon can usually shine some light through. Like other stratiform clouds, one usually can't detect distinct cells or sharp features. This picture shows the sun shining through a gray, diffuse cirrostratus overcast.

Middle clouds have many similarities to the cumuloform and stratiform high clouds. Since they are closer to a groundbased observer, the cumuloform elements in particular appear larger than their high cloud counterparts. They can contain ice crystals and/or water droplets and may occasionally be associated with some light precipitation.

- Altocumulus have distinct cloud elements and are either in a patchy, scattered distribution or can appear in linear bands. The altocumulus in this photo by Jay Shafer consists of a number of individual cloud elements. Jay also took this beautiful sunset photo of altocumulus clouds.
- Altostratus have a more uniform and diffuse coverage where it is difficult to detect individual elements or features. In this picture, a few altocumulus clouds in the foreground precede a more uniform deck (see arrow) of altostratus.

Low clouds are most often composed of water droplets, but can have ice crystals in colder climates. Some of these clouds can develop into the multi-level clouds and can go through various phases, such as, a morning stratus deck turning into late morning stratocumulus, then early afternoon cumulus, and vertical development into cumulonimbus which can produce heavy rain and possible lightning and thunder.

- Cumulus are usually puffy and often have very distinct edges and usually a noticeable vertical development. They often have a poporn-like appearance. Cells can be rather isolated or they can be grouped together in clusters as shown in this photo. The main cumulus cloud pictured in this view was nearly overhead, so the vertical extent is hidden from view. However, since the sun is on the other side of the cloud, its thickness is evident from the negligible amount of light passing through its center.
- Stratocumulus can be widely scattered (as depicted in this photo, but are usually concentrated closer together in clusters or layers and have very little vertical development. This photo of a stratocumulus layer from above was taken by Jay Shafer, a Plymouth State meteorology graduate, from Mt. Washington. Jay also went down to a lower elevation and took another photo providing a closeup, side view of a stratocumulus cloud in this deck. These relatively flat clouds usually lack the sharp edges and "popcorn" appearance of most normal cumulus clouds.
- Stratus are usually the lowest of the low clouds. Stratus often appear as an overcast deck (as shown), but can be scattered. The individual cloud elements have very ill-defined edges compared to most low cumuloform clouds (e.g. cumulus and stratocumulus).
- Fog can be considered as a low stratus cloud in contact with the ground. When the fog lifts, it usually becomes true stratus. This photo shows fog over the Pemigewasset River basin with clear skies elsewhere.

Multi-layer clouds are the heavy precipitation producers. The depth of these clouds give precipitation hydrometeors a better environment to develop and grow.

- Nimbostratus are often included in many texts as low clouds, but here they are considered multi-layer clouds because their vertical extent often goes well into the middle cloud region and these clouds often have even taller cumulonimbus clouds embedded within them. The clouds are very dark, usually overcast, and are associated with large areas of continuous precipitation. If it's a gray and rainy day as shown in this photo, the sky most will most likely be filled with nimbostratus clouds.
- Cumulonimbus, as shown in this photo (with cumulus in the foreground), are the clouds that can produce lightning, thunder, heavy rains, hail, strong winds, and tornadoes. They are the tallest of all clouds that can span all cloud layers and extend above 60,000 feet. They usually have large anvil-shaped tops (as shown) which form because of the stronger winds at those higher levels of the atmosphere. This first "cb" picture was taken by Plymouth State student Bill Schmitz from an airplane outside of the New York City area--note the three smaller turrets developing. Another picture shows a view from the ground of a cumulonimbus with a base at around 3,000 feet and vertical development upward to around 30,000 feet - small compared to most thunderstorms which are associated with really severe weather. Sometimes, strong cumulonimbus clouds can have appendages protruding from the base of the cloud, which are called "mammatus" clouds because they resemble the mammary glands of mammals. They indicate that the atmosphere is quite unstable and can also be an indicator of impending severe weather. The picture of mammatus clouds, shown here, was taken by Mark Gibbas, a Plymouth State meteorology alumnus, at Acadia National Park.

Orographic clouds, as the name implies, are produced by the flow of air interacting with mountainous terrain.

- Cap clouds form when air containing water vapor is uplifted on the windward slide of the slope and reaches saturation producing liquid water cloud droplets and a cloud which can "cap" the summit. The spectacular picture was provided by Michael Nahmias and shows the cap cloud shrouded summit of Mt. Ranier.
- Lenticular clouds are lens-shaped clouds that can result from strong wind flow over rugged terrain. At the time of this photo, the winds were blowing around 30-40 mph from right to left, forming several lenticular clouds. Sometimes they stack up like pancakes in multiple layers as are several depicted in this first photo. The strong flow produces a distinct up and down wavelike pattern on the lee side of the mountain or large hill and the lenticular clouds tend to form at the peaks of these waves. They sometimes are very round and the edges are so well defined that they resemble flying saucers. This close up sequence shows a large lenticular cloud at various stages of illumination as the sun moved lower on the horizon and lit the cloud from below. Another lenticular cloud can be seen in the background of the last frame of the sequence. These photos were taken on January 25, 1999 in Plymouth, NH, by James D. Rufo, a Plymouth State meteorology graduate. Mrs. Lorraine Brown of Bristol NH captured this same cloud formation from about 20-25 miles further away in these pictures. Lenticular clouds are often placed into the middle cloud category since they are most common at those altitudes. Plymouth State meteorology graduate, Jay Shafer, has also provided some stunning additional lenticular pictures taken around the White Mountain region of New Hampshire.

Another "specialty" cloud is one that can develop due to Kelvin-Helmholtz (K-H) instability waves and subharmonic resonance with other waves in the atmosphere. This can result in an intertwined or spiral cloud pattern as shown in this picture, which was also taken by James D. Rufo. H-H instability is the result of strong wind shear. K-H clouds that form in early stages can resemble well-organized waves that appear to be breaking like ocean waves.

Another type of cloud can be formed from the vapor contained in the exhaust of a jet engine of an airplane when they are flying at high enough altitudes where cold temperatures cause the vapor to turn into ice crystals like cirrus clouds. These clouds are called "contrails" (short for "condensation trails") and look like lines in the sky. The photo shows two contrails. The one on the lower right was formed by a jet that flew a few minutes ahead of the jet which formed the contrail in the center. The newer contrail is narrower and hasn't had the chance to diffuse like the older one.

Return to Plymouth State Weather Center

Another useful cloud information resource is the U of Illinois Cloud Catalog.

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*For more information or comments, contact **Jim Koermer** at koermer@mail.plymouth.edu.*

A review of theoretical and observational studies in cloud and precipitation physics: 1991-1994

Roy M. Rasmussen

National Center for Atmospheric Research, Boulder, Colorado, USA

U.S. National Report to IUGG, 1991-1994

Tips for Painting Clouds

---

tttrains' Home Page | World of DCC | Train Shops | Modeler's Corner | Showcase | What's New?

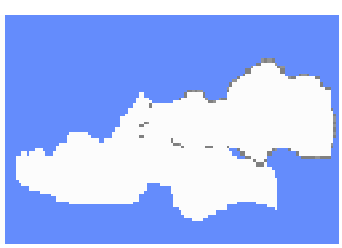
Skies and Cloud Stenciling

Here are some tips and ideas that I have taught in clinics and to other modeling friends. This technique takes practice and perseverance. I have stenciled with sponge application, spray application and of course, dry brush, but nothing beats spray for speed.

I have used large stencils with children for murals, posters , and scenery for plays, projects, and art work.

Stenciling has the benefit of immediate success. Once the painter realizes the needs of a dry bush and a little amount of paint, success usually follows. It is always best to practice on large cardboard, poster, or a wall that you are willing to repaint.

Creating distance or a quick lesson in perspective!

Smaller objects appear further away
Overlapped objects appear behind
Objects in the distance have softer edges
Objects in the distance appear grayer

Lower objects seem further away
Higher objects appear closer

Supplies:

Oak tag stencils see: Walther's catalogue, New London Industries : or for the do it-yourselfer make your own stencils. The nice thing about homemade is that your cloud shapes are not on somebody else's backdrop.

Spray Paint (Krylon Variety) Flat White, Light Gray
Latex Gloves
Protective mask- breathing type
Eye goggles

Making Stencils:

1. Take slides of desired weather conditions, sharp clear edges of clouds are best
2. Project slides onto wall.
3. Hold (length wise)oak tag (at least 12x18 sheets or bigger) against wall and trace random edges of clouds
4. Cut with sharp knife, razor, or embroidery scissors
5. The result is two stencils
6. Produce 8-10 different stencils for best results

Preparation:

1. Sand, spackle, or fill gouges, resand with finer grade paper, and prime two coats
2. Paint two coats
   - I use Sherwin William's #SW1787 Baby Blue or Sherwin William's #BM 33-4 Universe Blue, which is a more intense blue than Baby Blue. Any other good quality latex is fine, but avoid greenish blues or purplish blues
3. Decide what type of clouds: stratus, cumulus- this will somewhat be determined by your stencils
4. Decide what type of weather a (i.e. arid desert will have more intense blue with less horizon haze, but urban areas will have smog and haze.

Procedure:

1. VENTILATE THE ROOM!!!!!
2. Faintly sketch in main clouds

3. How to use stencils
    - Hold by the straight edge
    - Float the stencil above the surface
4. Change stencils often
5. Never spray near the side edge
6. Change position of stencils between blasts of paint: clouds will appear 3-D with the different layers of paint
7. For the tops of clouds- hold the stencil 1/2 inch away from wall, giving a sharp edge
8. For the bottoms of the clouds-hold stencil 1-2 inches away from wall, giving a soft fuzzy edge
9. Begin with the small horizon clouds: these multiple horizon clouds will receive overspray from the clouds above them, thereby creating atmospheric haze

---

Helpful Hints:

1. Keep clouds random and uneven
2. Atmospheric haze is valuable in creating the feel of distance, the haze should be gradual from intense blue to bluish white at the horizon. This happens automatically from the overspray, just as long as you start at the bottom of your back drop.
3. Decrease cloud size from top to bottom of backdrop
4. Use paint sparingly
5. Overlap edges (especially in the lower areas)
6. Stencil interior edges inside the larger clouds
7. PRACTICE, PRACTICE, PRACTICE
8. For modules, have partial clouds go off the ends of your backdrop or show just the bottom of an overhead cloud

From a reader! Dan Crockett

My layout room is 12'6" x 33'4" and I have three walls painted with clouds on intense blue sky (that's what we have in the west). I used the stencil idea with Krylon spray for the clouds, but for the darker clouds, I found that Krylon Aluminum is very effective and realistic--much more so than the use of gray. Of course, one must use it lightly.

Also, always paint the sky and clouds before painting mountains or buildings in order to get a three dimensional effect. Don't be afraid of the sky and clouds coming through. The mountains and buildings will hide them just as they do in real life.

Finally, eastern mountains have much more haze than western mountains. Use a white, LIGHT overspray to simulate the haze and give the effect of mountains in the distance.

1.

Cautions or some common mistakes:

1. Clouds are too solid from too much paint, the best way to keep clouds airy is with short bursts of spray and keep moving the stencil to the next area
2. Use light gray very lightly, only on the underside of your darkest cloud, apply gray first then apply white, the use of inclement weather can be very effective.
3. Never spray near the straight edges of a stencil, it is impossible to remove that hard white edge, if this mistake happens, the easiest solution is to repaint over the goof with your sky blue.
4. Watch out for repeated shapes, the human eye quickly picks up on identical forms and lines, avoid this by changing stencils and having a large number of stencils, let them dry and flip them for more variety of shape
5. Try your best not to hit the recently sprayed paint with your stencil, fingers, hat bill, etc. It's best to spray in a small area, say 18 inches or so, then move on, to return to the dry area and add more clouds higher on the backdrop

Good Luck with your stenciling efforts!

Last Updated November 5, 1996

For more information contact Debbie Ames, owner ***tttrains***

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economic impacts
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User Interface
graphics text

Graphic by: Yiqi Shao

Periodically, the flourishing fish populations commonly found off the west coast of Peru South America are replaced by the sight of dead fish littering the water and beaches. Unusual weather conditions occur around the globe as jet streams, storm tracks and monsoons are shifted. Such disarray is caused by a warm current of water that appears every three to seven years in the eastern Pacific Ocean called El Niño. This module introduces El Niño, conditions are responsible for its occurrence, plus the impact it has on the rest of the world. The El Niño instructional module has been organized into the following sections:

Sections

Last Update: 04/28/98

Definition

Introduces El Niño, when El Niño events have been recorded and how it compares to La Niña.

'97-'98 Event

Provides a brief insight into the most recent El Niño event.

Upwelling

Introduces upwelling, the thermocline and how they impact local sea life populations.

Non-El Niño Years

Typical oceanic and atmospheric conditions that exist in the tropical Pacific when no El Niño is present..

El Niño Events

Conditions that lead to an El Niño event and how El Niño influences upwelling processes, tropical rainfall and local fish populations.

Sea Surface Temperatures
El Niño visualized through sea surface temperature anomaly plots.

Impacts on Weather
The influence of El Niño on weather conditions worldwide.

Economic Impacts
Reduction in local fish populations, which in turn affect local industry and market prices worldwide.

Detection and Prediction
Methods and resources used by NOAA for detecting and predicting the presence of El Niño.

Acknowledgments
Those who contributed to the development of this module.

The navigation menu (left) for this module is called "El Nino" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Precipitation

definition

- Arctic Mountains
- Arctic Tundra
- Atlantic
- Great Lakes
- Mackenzie District
- N.E. Forest
- N.W. Forest
- Pacific Coast
- Prairies
- Southern B.C.
- Yukon

Welcome

What is La Niña?

Current Status and Forecast

Comparing La Niñas

Global Effects

Canadian Effects

Further Readings

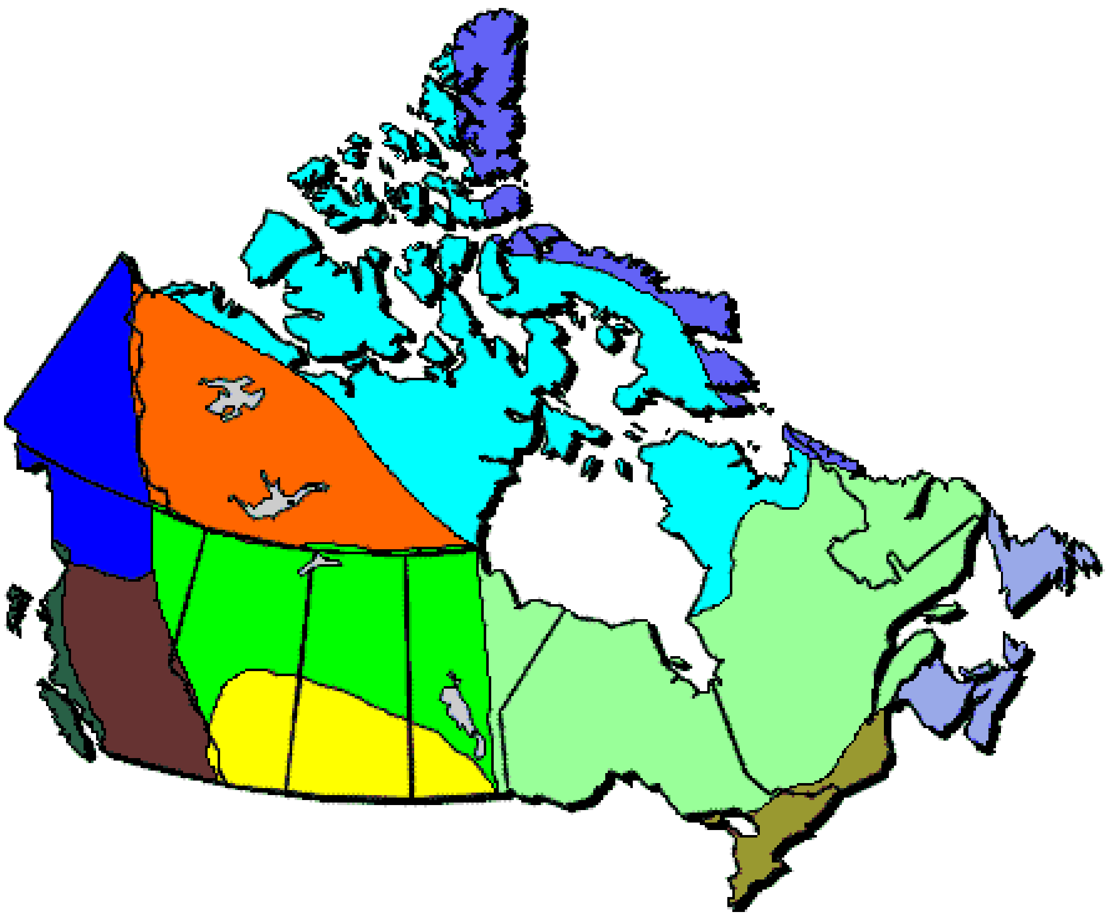
El Niño

Other Educational Sites

La Niña

Canadian Effects

View the general effect of La Niña on all of Canada (including effects on specific cities across Canada). Or, select the desired region from the map or legend below.



Based on physical, ecological and climatological homogeneity, 11 broad-scale Climate Regions are defined for Canada. These regions provide a convenient framework for spatially organizing and analyzing climate data, and for detecting regional and national climate trends.

Canadian Regions: [All of Canada]

Arctic Mountains Arctic Tundra Atlantic

Created : 2002-08-08

Modified : 2003-09-12

Reviewed : 2003-09-12

Url of this page : http://www.msc.ec.gc.ca/education/lanina/canadian/index_e.cfm

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08/06/2004 - Updated 11:18 AM ET

Resources: El Niño and La Niña

Latest forecasts, technical discussions

- NWS, CPC: Technical discussion of observations, forecasts
- IRI; Global outlooks and discussions
- Australian Bureau of Meteorology: El Niño Warp Up

How El Niño and La Niña work

- What is El Niño?
- How El Niño/La Niña fit in with other climate patterns
- Graphic: How El Niño begins
- Graphic: How El Niño affects weather
- NOAA PMEL: Details on what is El Niño
- Scientists bog down in El Niño's impact on Antarctica
- El Niño found to affect Antarctic sea ice
- NOAA Magazine: The economic implications of El Niño
- 97-98 El Niño may have been more good than bad

Questions and answers

- NOAA: El Niño, La Niña FAQ
- Answers to Ask Jack questions about El Niño

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- Forecasts for U.S. cities
- Forecasts for global cities

Today's Top Weather Stories

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" Tropical Storm Gaston hits South Carolina - 1:15 PM
" Arctic Ocean both cools and warms Barrow, Alaska - 1:49 PM
" Arctic expedition seeks ancient climate record - 3:26 PM
" Tampa radar failed before Hurricane Charley hit - 8:32 AM

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NOAA-CIRES Climate Diagnostics Center

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You are at: CDC Home ENSO information

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ENSO pages:

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  - Current conditions
  - Climate associations
  - Historical ENSO
  - Current CDC research topics
  - Forecasts
  - Other information
- Climate Effects
- Current ENSO
- Current Climate
- References
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- Glossary
- FAQ

El Niño/Southern Oscillation (ENSO)

Science Background

- What happens during an "El Niño/La Niña" cycle? *Example: A 3-D animation of the tropical Pacific ocean during a simulated ENSO cycle.*
- Annual Cycle: what is normal for the atmosphere and ocean?

Current Conditions

- What is the current state of El Niño/La Niña?
  - Latest SST Animation.
  - Most recent ENSO index time-series plot.
  - Latest Tropical Pacific SST time-longitude crossection.
- Current climate maps.
- Current projection of SST onto ENSO optimal structure.

Climate Associations

- Climate: What have been historical climate relationships to ENSO? *Compare the climate of El Niño and La Niña.*
- Individual weather systems as affected by ENSO.
- Differences between recent El Niño and La Niña events.

Historical ENSO

- What years are ENSO years?
- Long-term ENSO time-series.
- SST Animations during past events.

Current CDC Research Topics

- Influence of ENSO on medium range forecasts.
- MEI (Multivariate ENSO Index).
- Linearity of the ENSO Signal.
- ENSO SST predictions from Linear Inverse Modeling.
- CDC ENSO publications.
- CDC research topics.

Forecasts

- Forecasts and advisories, including CDC's linear inverse modeling and CCA ENSO forecast.

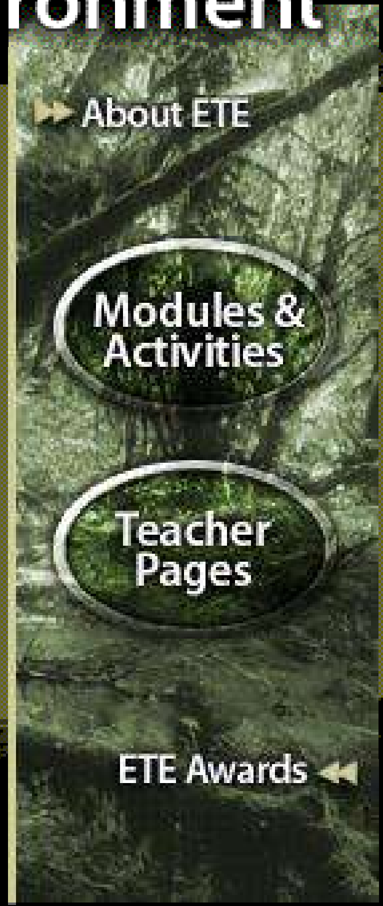
Other Information

- FAQ
- Educational resources for teachers and the interested public.

- Other ENSO Web Pages.
- glossary of terms.

NOAA-CIRES Climate Diagnostics Center
Document maintained by Cathy Smith (cathy.smith@noaa.gov)
Updated: Jun 30, 2004 13:38:39 MDT
http://www.cdc.noaa.gov/ENSO/index.shtml

Exploring the Environment®



The U.S. Environmental Protection Agency estimates that 10 percent of the world's coral reef population has already been damaged, and a much higher percentage is threatened. Exploring the Environment's new coral reefs module takes a comprehensive look at this real danger to Earth's biodiversity and why it should concern us. Check out the Modules and Activities section for this look at coral reefs along with many other real-life environmental issues.

Attention, teachers, we need your help! We would like you and your students to provide feedback on ways to improve the Exploring the Environment® web site. Your evaluation will be based on the teaching approaches you already use for Exploring the Environment. To find out more, e-mail researchcf@cet.edu.

Related Web Sites

- K4 Earth Science Modules
- Earth Science Explorer
- NASA COTF Web Site
- CET Web Site

For questions, comments, or more information concerning ETE, please contact Dr. Robert Myers, senior instructional designer/project manager for the ETE web site.

ETE is made possible through a cooperative agreement with the NASA Goddard Space Flight Center and is supported by NASA's Learning Technology Program (LTP),

New Module: Coral Reefs

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K4 Earth Science Modules | Earth Science Explorer | Sitemap | COTF | CET

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Site maintained by the ETE Team
Last updated on March 09, 2004

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El Niño Theme Page

access to distributed information on El Niño

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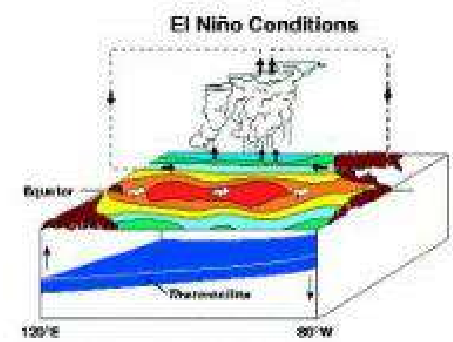
What is El Niño?
Frequently asked questions (FAQ)
More FAQ's
Impacts of El Niño
Benefits of El Niño prediction
Spanish and Portuguese language sites
Visit an El Nino Observing System
Watch videos of climate observation research cruises.

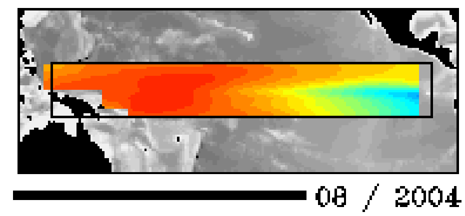


El Niño and Normal and La Niña conditions

El Niño to blame?

What is happening now?

Latest information about El Niño
Forecasts
Realtime data, products and analyses
List of impacts and prediction benefits
3D Animation of El Niño temperatures
More El Niño animations and graphics



Pacific equatorial sea surface temperatures (animations)

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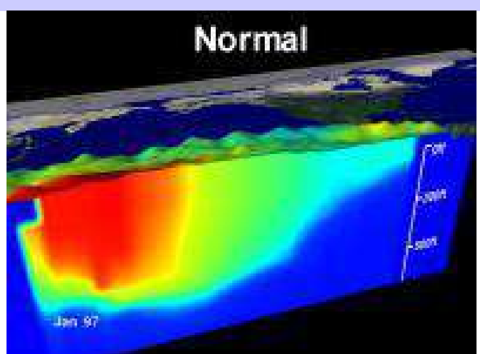
Numerical model simulations
Ka'Imimoana shipboard data
NOAA data via the NOAAServer



Normal, El Niño and Developing La Niña

skip navigation

Welcome

This site is a joint effort of the NOAA Research and the College of Education at the University of South Alabama (USA). The goal of the site is to provide middle school science students and teachers with research and investigation experiences using on-line resources.

What is NOAA Research?

NOAA Research is an organization of the United States Government. To find out more about the important role of NOAA Research, click on NOAA Research INTRO.

To use this site as it is designed, click on TECH INFO. From this area you can download needed software and the Student Activity Books that complement the on-line science lessons.

What's in this site?

To view a short description of the parts of the site and the educators who developed it, click on OVERVIEW.

For Teachers

Click on the Apple icon at any time to download teaching materials for each topic. This information includes lesson objectives, interdisciplinary uses, NSTA and AAAS standards, and teacher preparation material.

Home | El Nino | Storms | Atmosphere | Fisheries | Great Lakes | Oceans | Teacher

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Science with NOAA Research
Updated July 13, 2004

TV Web Markers: El Niño's Reach Across the Globe | El Niño's Ground Zero | Global Weather Machine | El Niño's Reach through Time | El Niño's Reach into Living Things

Next to the seasons, El Niño is the most powerful force driving global weather. Find out what scientists are learning about this mysterious weather phenomenon and its reach through space and time.

Photo: NASA Goddard Space Flight Center.

Anatomy of El Niño | Chasing El Niño | El Niño's Reach
Dispatches | Resources | Mail | Site Map

NOVA Online | Editor's Picks | Previous Sites | Join Us/E-mail | TV/Web Schedule
About NOVA | Teachers | Site Map | Shop | Jobs | Search | To print

NOVA Online is produced for PBS by the WGBH Science Unit
Major funding for NOVA is provided by the Park Foundation, The Northwestern Mutual Life Foundation, and Iomega Corporation.

Arctic Theme Page

This "Theme Page" has links to two types of resources related to the study of Arctic. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) that will help teachers provide instruction in this theme. Please read our disclaimer.

- Animals of the Arctic

  This ThinkQuest Junior site has good articles on a dozen animals found in the arctic.
- Antarctic Theme Page

  See this CLN theme page for resources on polar studies - but with a focus on the Antarctic.
- Archaeology in Arctic North America

  An overview of some archaeology research recently undertaken in the north. The focus of the research is to understand the origins and migration of different Inuit-Eskimo groups. The site also reports on the unique challenges of conducting the research in Canada's High Arctic regions.
- About Arctic Animals

  Over a dozen links to sites with information about animals living in the arctic region.
- Arctic Circle

  A comprehensive site presenting many concerns from Alaska's north. It offers information on aspects of Alaska's Natural Resources, History and Culture, Social Equity and Environmental Justice plus much more.
- Arctic Explorer

  The Surface Heat Budget of the Arctic Ocean - Joint Ocean Ice Studies (SHEBA-JOIS) is a special project to gather information helping scientists understand how arctic air, sea, and ice interact to affect the global environment and to understand arctic ecosystems.
  - Arctic Life Small descriptions for Arctic Wolves, Polar Bears, Musk Oxen, Gulls and Walrus.
  - Photograph Gallery See photos of the Science Village, the icebreaker, and the icy airstrip.
  - Polar Bear Fact Sheet Provides an overview of the issues regarding the Polar Bear's life cycle.
  - Quiz
    Try the on-line quiz about Arctic issues.
  - Ship to Shore: A Personal Story Read the logs kept by one of the Department of Fisheries scientists working on the project.

- [Arctic Studies Centre]

The Smithsonian's Arctic Studies Center is dedicated to the study of northern peoples, their history and environment and offers a variety of virtual exhibits.

- Arctic Wildlife Portfolio

"Biologist Doug Siegel-Causey shares his knowledge and special insights about this icy world and it's [sic] inhabitants." The site is divided into the following sections:

  - Arctic Wildlife Glossary More than 10 Arctic terms defined.
  - Birds Includes pages for: Albatross, Bald Eagle, Peregrine Falcon, Ptarmigan, Puffin, and Snowy Owl.
  - Mammals Information on: Arctic Fox, Caribou and Reindeer, Lemming, Musk Ox.
  - Polar Pairs A Java based game of concentration using pictures of Arctic wildlife for students to match.
  - Sea Mammals Links to: Beluga Whale, Orca, Polar Bear, Sea Otter, Seals, Walrus

- Biome Investigation

Students use science process and research skills to investigate the six biomes of the world. These activities are designed to enhance an integrated unit on biomes through the use of visual resources.

- Canadian Museum of Civilization: First Peoples Hall and Archeology Hall

Some of the features of this site include: Native People, Emergence, the Haida, and Inuit 3D, which requires downloading a Virtual Reality plug-in.

- Conservation of Arctic Flora and Fauna (CAFF)

CAFF is a cooperative environmental protection program adopted by Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden and the United States Scientific documents on habitat and species conservation. Their goals are to protect, conserve and restore the Arctic environment, conserve Arctic flora and fauna, and address the special role of the indigenous people of the Arctic in pursuit of these goals. Note: the scientific documents within the site would not be appropriate for younger students.

- Naming the Islands of Canada's Arctic

Discover how each of the northern Arctic islands received their names.

- Not Alone on the Ice

Intermediate/junior high students test the insulating properties of various materials while designing a South Pole research station in this 10 period teaching unit from the National Science Foundation. Although Antarctica is the focus, the content should be generalizable to polar regions in general.

- Nunatsiaq News

The Nunatsiaq News web site features the Nunavut and Nunavik editions of Nunatsiaq News, all rolled into one.

- Polar Connections: Exploring the World's Natural Laboratories

  Elementary/junior high students assume the role of polar researchers in this collection of teaching/learning activities from the National Science Foundation.

- Polar Continental Shelf Project

  This site from Natural Resources Canada has links to Animals, Plants, Humans, Geography, a Photo Gallery, and an interactive Quiz to text your knowledge.

- [The] Siberian Arctic

  Through this lesson plan from National Geographic, high school students will learn about: the habitats of northwestern Siberia; reindeer and their role in biodiversity; oil and natural gas reserves and the environmental consequences of tapping these resources; and threatened regions elsewhere in the Arctic.

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Note: The sites listed above will serve as a source of curricular content in Arctic study. For other resources in Socials Studies (e.g., curricular content), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

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Glaciers Theme Page

Here are a number of links to Internet sites which contain information and/or other links related to the specific theme of glaciers. Please read our disclaimer.

- ## Fundamentals of Physical Geography

  Although this online textbook from Michael Pidwirny, Okanagan University College, is intended for postsecondary students studying introductory physical geography, much of it may be applicable for high school students as well. Contents include over two hundred pages of information, more than three hundred 2-D and animated graphics, an interactive glossary of terms, a study guide, links to other Internet resources, and a search engine. See the Table of Contents to directly access the Geomorphology section with several chapters on glaciation.

- ## Glacial Features of North Dakota

  A site with illustrated descriptions of a number of glacial features in North Dakota. These include: End Moraine, Erratic, Esker, Ice Thrust Mass, Ice-walled Lake, Kame, Meltwater Channel, Outwash, and Till.

- ## Glacier

  Glacial geologists from Rice University designed and developed this page. It has information about what a glacier is and descriptions about some special features of ice. These features about ice include its shape, size, movement landscapes, environments and age.

- ## Glaciers (The Cryosphere)

  National Snow and Ice Data Center (NSIDC) menu has links to definitions for what a glacier is, how they move, how they are formed, what the components are, and more.

- ## Glaciers (Snowtastic Snow)

  Part of a Think Quest Junior (TQJ) project, this page describes several characteristics of glaciers. It describes how a glacier is formed, how a glacier moves, the size of a glacier, and the life that depends on glaciers.

- ## Glaciers and Glaciation

  From the U.S. Geological Survey Cascades Volcano Observatory, this page has links to descriptions of Glaciers, Ice Sheets, Glacier Hazards and Glacier Outburst Floods. In addition, there are four links to information about Mount Rainer and Mount Hood glaciers and glaciation.

- ## Glaciers and the Glacial Ages

  Focused on Vermont, U.S.A., the information on this page investigates what glaciers are, the physical effects from glaciers, when do Ice Ages occur, and when did the last glacial age end.

Ice Ages

Illinois State Museum presents information about the North American continental glaciers. They provide answers to the following questions: What are Ice Ages?, When did Ice Ages occur?, and Why do Ice Ages occur?.

Ice Ages and Glaciation

Geology instructors from Hartwick College has posted the following four links to help support their geology students. It presents illustrated descriptions of glacial features from around New York.

- Ice Ages and Glaciations This page illustrates how to gather evidence about the glacial period.
- Ice Ages and Glaciations Part II Shows how the motion of ice creates characteristic landforms.
- Ice Ages and Glaciations Part III An example a U-shaped valley and discussion of the impact of a piece of ice detaching from the glacier as it retreats.
- Ice Ages and Glaciations Part IV Illustrated information about what causes an ice age.

Illustrated Glossary of Alpine Glacial Landforms

As part of a university course in geology, this glossary has illustrations that are divided into the following three glacial categories: Erosional Landforms, Depositional Landforms, and Ice Features.

Recipe for a Small Glacier

As a class demonstration, teachers can use ice cream, some chocolate cookies and marshmallow syrup to imitate how a glacier moves (oozes).

[The] Retreat of Glaciers in the Midwestern U.S.

Animated illustrations and five maps are used to show retreating glaciers in North American from 18 000 to 6 000 years ago. An MPEG video is also available if your browser can support it.

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Note: The sites listed above will serve as a source of curricular content glaciers. For other resources in science (e.g., curricular content in Earth Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Avalanches Theme Page

CLN Theme Pages

Below are the CLN "Theme Pages" that supplement the study of avalanches. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Glaciers Theme Page
- **Natural Disasters**
  - Blizzards and Snow Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Avalanche Resources

Here are a number of links to other Internet resources that contain information and/or other links related to avalanches. Please read our disclaimer.

- Avalanche Articles

  A series of articles from Colorado Firstrax Webzine. Titles include: Early Season Avalanche Notes; Identifying Weak Layers In A Snow Pit; Avalanche Beacons and Their Use; Traveling In Avalanche Terrain; Anatomy of A Slab Avalanche; Snow Block Analysis: A Better Way...The Stuff Block Test; Spring Avalanches; and What To Do If Caught In An Avalanche
- Avalanche Awareness

  A primer on avalanches from the National Snow and Ice Data Center in Colorado.
- Avalanche Awareness

  A tutorial on avalanches from the Manti-La Sal Avalanche Center in Utah.
- Avalanche Beware

  A series of articles from the Canadian Ski Patrol Association on the Discover the Rockies

Website. Titles include: Recognizing Avalanche Terrain; Could the Snow Slide? Safe Travel; Nature's Billboards; The Human Factor in Avalanches; When Travelling In Avalanche Terrain; Avalanche Rescue - What to Do; and The Avalanche Danger Scale.

- Avalanche Defense Page

  Avalanche defensive systems (active and passive) and "zoning" are described.

- Avalanche Dogs

  A wide range of information on avalanche dogs is available at this site, including how dogs are selected and trained, a dog behavior policy, and links to other sites on search and rescue (SAR).

- Cyberspace Snow and Avalanche Center

  This site serves as a metalist of links to educational resources on avalanches. Some links are to their own documents and others are to external resources. Categories of information include: Basic Information; Snow Stability and Snow Testing; Avalanche Dogs, and Miscellaneous Topics.

- Avalanche

  Avalanche lesson plan for grade 6-8 students.

- Nova Online: Avalanche

  Information on the making of a PBS special that aired in 1997. Check out in particular the sections titled "Elements of a Slide" and "Snow Sense" for basic background information on avalanches. There's a teachers' guide available if you wish to purchase a copy of the video.

- Westside Avalanche Network

  A wide range of information on avalanches is available at this site. Use the home page link above or go directly to some of their educationally relevant information below.

  - Avalanche Accidents Several years of statistics for Canada and the U.S. on avalanche fatalities and close calls.
  - Moonstone Snow and Avalanche Library Access to papers that contain information about snow and avalanches. Some of these papers form the basis of current avalanche education courses.
  - Picture Page Avalanche pictures in jpeg form.

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Note: The sites listed above will serve as a source of curricular content in Avalanches. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

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Screen

Earthquakes Theme Page

Below are the CLN "Theme Pages" which may supplement the study of earthquakes. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page
  - Volcanoes Theme Page

General Earthquake Resources

This "Theme Page" has links to two types of resources related to the study of earthquakes. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- ## [The] ABC's of Plate Tectonics

  "A broad analysis of the basic principles that should apply to the movements of plates, some new hypotheses about how they apply to convection and landform formation, and some expected scenarios for differing tectonic events."

- ## Big Trouble in Earthquake Country

  In this four day unit plan, high school students use on-line data to hypothesize what would happen to life and property from earthquakes of various magnitudes. They then develop strategies to minimize damage and loss of life in their home town area.

- ## Canadian National Earthquake Hazards Program

  Lots of information on Canadian earthquakes, including reports of recent earthquakes in or near Canada, maps, and plots of seismograph network recordings. In addition, there are links to reports on specific earthquakes, regional reports, and Q&A files. An archive of seismographical data is also found at this site.

- ## Candy Quakes

  In this lesson plan, grade 8 students use candy bars, gum, and licorice sticks to learn how deformational forces affect the earth's crust. It's probably safe to say that this unique lesson will energize your students - both before and afterwards.

- Earthforce in the Crust

  The Franklin Institute Science Musuem provides a brief description of plate tectonics followed by a well defined set of external links to earthquake resources. Headings include: Current Quakings, Plate Tectonics, Earthquake Science, Teacher Lessons, Interactives, History, and Preparedness.

- Earthquake Information

  The United States Geological Survey site contains a meta list of links to latest quake information (maps and lists), information on hazards and preparedness, earthquake FAQs and information, and links to other resources.

- Earthquakes

  The U.S. Federal Emergency Management Agency sponsors this "FEMA for Kids" site on earthquakes. There are over 10 lessons/activities specially designed for children.

- Earth's Interior & Plate Tectonics

  An instructional document divided into section on "The Earth's Interior " and "The Lithosphere & Plate Tectonics" (Oceanic Lithosphere, Continental Lithosphere) and "Plate Tectonics").

- Encarta Online: Eye on Earthquakes

  In the process of developing their own TV News Shows, grade 4-9 students learn about the history of earthquakes, the formation of continents, and earthquake measurement and prediction.

- Every Place has its Faults

  An explanation, complete with animation, on the four basic types of faults.

- Faults, A Model of Three Faults

  Grade 7-12 students use a model of the earth's surface to learn about fault movements in this lesson plan from the USGS.

- The Great 1906 Earthquake and Fire

  From the Museum of the City of San Francisco, this Website explores the earthquake of 1906 through photographs, eyewitness accounts, newspaper clippings and reports from departments and organizations of the time. You can also find information on the 1989 San Francisco earthquake.

- ISU's Earthquake Home Page

  This site at Indiana State University lists the date, time, and shows the ticker-tape for the most recent earthquakes.

- Musical Plates

  In this multidisciplinary project, elementary grade students can learn about earthquakes through activities that use real time earthquake data as well as language art activities that look at how earthquakes affect our lives. There is also a teacher's area to assist educators in implementing this project in their classroom.

- ## National Earthquake Information Center

  This US site provides information on current earthquakes and earthquakes in general as well as links to other information sources.

- ## New York Times Learning Network

  These lesson plans use New York Times articles as a starting point.

  - Admidst the Rubble of Ruined Cities In this lesson plan, grade 6-12 students develop an understanding of the impact an earthquake could have on a country by developing and proposing solutions to rebuild Columbia's infrastructure in the wake of the January 25, 1999 earthquake.
  - National Tragedy, Global Response Grade 6-12 students "explore how different people on local, national and international levels respond to a destructive natural disaster and the needs of its victims and how various facets of the media cover such an event, focusing specifically on the earthquake that devastated Turkey on August 17, 1999."
  - Outreach in the Aftermath Grade 6-12 students "investigate the many types of aid needed to help Turkey recover and rebuild in the wake of the earthquake that devastated a large portion of the country on August 17, 1999. "

- ## Origami Activities

  An activity from the New Mexico Bureau of Mines and Mineral Resources, students can make a hexaflexagon with earthquake-education themes.

- ## Pacific Geoscience Centre, National Earthquakes Hazard Program

  Along with current earthquake information for Western Canada, there are a number of educational resources for teachers including All about Earthquakes: Frequently Asked Questions, This Day in Earthquake History, and Earthquakes in Eastern and Western Canada.

- ## Plate Tectonics

  Nasa's Observatorium presents an article on plate tectonics for students in grades 6-9 which presents the theory of plate tectonics in easy-to-understand concepts. There's also a teacher's guide, but you'll have to read through the article to find it.

- ## The Restless Planet: Earthquakes

  This PBS online site (based on the Savage Earth series) explores earthquakes through the article: "Earth: All Stressed Out." For more information, check out the three sidebars: Learning from Earthquakes, Quake Prediction, and Build Smart, Not Hard. The site has Flash and QuickTime animations.

- ## Shake, Rattle, and Roll

Two hands-on teaching activities for elementary/junior high students from the National Science Foundation. In the first, students explore structural design by constructing buildings that can withstand simulated earthquakes. They then design a series of experiments to explore the relationship between type of groundand the degree of damage a building is likely to sustain.

- Surfing for Earthquakes and Volcanoes

  In this week long lesson plan, middle school students research earthquakes and volcanoes on the Internet. Topics include: continental plate boundaries; interaction between plate boundaries; causes of earthquakes and volcanoes; and the comparison of the formation of Olympus Mons on Mars and the Hawaiian volcanic chain.

- Surfing the Internet for Earthquake Data

  This site is a meta-list of links to sites where seismic information of one kind or another is available.

- TrackStar

  TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

  This link is to their search page from where a keyword search on "earthquake" will produce numerous hits. Caution #1: Many (most?) of the web sites that these lessons access will already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

- **UNR Seismological Laboratory**

  The Nevada Seismological Laboratory at the University of Nevada, Reno has prepared six documents containing explanations, maps, and illustrations for the following earthquake topics.

  - Earth's Interior
  - Earthquake Effects
  - [The] Modified Mercalli Scale of Earthquake Intensity
  - Plate Tectonics, The Causes of Earthquakes
  - Seismic Deformation
  - What is Richter Magnitude?

- [The] Virtual Times: Recent Earthquakes & Active Volcanoes

  Maps and figures of recent earthquakes.

Note: The sites listed above will serve as a source of curricular content in Earthquakes. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Tsunamis Theme Page

Below are the CLN "Theme Pages" which supplement the study of tsunamis. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- ### Natural Disasters
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Volcanoes Theme Page

General Tsunamis Resources

Here are a number of links to other Internet resources which contain information and/or other links related to tsunamis. Please read our disclaimer.

- ### Activity Search

  Here are two lesson plans at the Houghton Mifflin Activity Search site that will help students understand tsunamis better.
  - Let's Make Waves Children use wind to create waves and marbles to model energy moving through water.
  - Monster Waves Students construct a tabletop village to visualize the relative height and effects of tsunamis.
- ### British Columbia Provincial Emergency Program

  The BC Provincial Emergency Program is the agency responsible for maintaining awareness, preparedness, and the response and recovery programs that are designed to reduce the human and financial costs of emergencies and disasters in BC. Included in the site is an online version of BC Tsunami Warning Plan, as well as general and BC specific information.
- ### Sensing Tsunami

  In this one day lesson plan, grade 9-12 students will develop a model for tsunami detection that incorporates remote sensing technology, will access data at remote sensing site via the

Internet, and will use the computer to prepare and archive a presentation of their final report.

- Tsunami: The Big Wave

  Nasa's Observatorium offers informational resources for students to explain what a tsunami is, the physics behind the wave, warning systems, what to do when they hit, and casualties data. A quiz and word search activity are also provided.

- Tsunami!: The WWW Tsunami Information Resource

  General information on tsunamis including near real-time tsunami informational bulletins, explanations of how a tsunami is generated and how it propogates, their effect on humans, how you can protect yourself, and a description of the Tsunami warning system. There is also survey and research information.

- Tsunami Database

  The National Geophysical Data Center's searchable database of recent and historical tsunamis.

- [The] Tsunami Page of Dr. George P.C.

  A very comprehensive site on tsunamis by Dr. George Pararas-Carayannis. In addition to general information, there are sections on Impact on Society; Mechanism, Propagation, and Terminal Effects of Tsunami; Historical Tsunami Database; Tsunami bibliographies; Warning Systems; and Real Time and Long Term Tsunami Prediction and Evaluation. Warning: The design of the main menu page incorporates small font size and questionable colour combinations which make the page very difficult to read. The lower pages are not quite as bad, but you may wish to override font and colour preferences with your own. Also, as this is a Geocities site, you will have to endure intermittent forced interruptions from their promotional advertising. If you can put up with these problems, the content in the site is worthwhile.

- Tsunami: The Great Wave

  An online brochure liberally sprinkled with pictures. Topics include: general information, causes of tsunamis, warning centres, warning dissemination, facts, and what you should do.

- Tsunami Warning

  Intended for elementary students, this online booklet contains 30 sequential pages of artwork and story. Caution: you may encounter slow downloads.

- Understanding Waves

  This lesson plan will give Grade 3-5 students a basic understanding of the physical properties of waves in general.

- Waves of Destruction: Tsunamis

  This web site is a companion piece to the PBS series on the Savage Earth but it can stand alone as well. Included is information on how tsunamis are formed and what makes them dangerous. There are also explanatory pictures and animation.

- Westcoast and Alaska Tsunami Warning Centre

This centre serves as the regional Tsunami Warning Center for Alaska, BC, Washington, Oregon, and California. Their web site contains recent press releases/advisories, information on recent tsunamis, an explanation of the physics of tsunamis, a list of safety rules, and a selection of pictures.

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Note: The sites listed above will serve as a source of curricular content in Tsunamis. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Volcanoes Theme Page

Below are the CLN "Theme Pages" that supplement the study of volcanoes. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans), which will help teachers provide instruction in this theme.

- **Natural Disasters**
  - Avalanches Theme Page
  - Blizzards Theme Page
  - Earthquakes Theme Page
  - Floods Theme Page
  - Hurricanes Theme Page
  - Tornadoes Theme Page
  - Tsunamis Theme Page

General Volcanoes Resources

Here are a number of links to other Internet resources that contain information and/or other links related to volcanoes. Please read our disclaimer.

- Earth's Active Volcanoes

  Location, updates, images, and information on active volcanoes in the world, by geographic region.

- [The] Electronic Volcano

  A meta-list of links to volcano Websites.

- Exploring Planets in the Classroom:Volcanology

  Five hands-on activities that are provided in classroom-ready pages for both teachers and students for exploring volcanology.

- Exploring the Environment: Volcanoes

  This module is part of "Exploring the Environment" (ETE) from NASA's Classroom of the Future. In ETE, high school students are faced with a real life problem, and their goal is to use problem-solving skills and internet-based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the volcanoes module, click on "Modules and Activities" and then "Volcanoes." Students will have four situations from which to choose.

- Global Vulcanism Program

From the Smithsonian Institution, the GVP "seeks better understanding of all volcanoes through documenting their eruptions--small as well as large--during the past 10,000 years." Check out their monthly Bulletin of the Global Volcanism Network (and archives) for on going eruption reports from local observers. Access names (and in some cases eruption reports) on volcanoes thought to have been active in the last 10,000 years, either geographically or alphabetically.

- Link-to-Learn Classroom Activities

Link-to-Learn contains classroom activities (or lesson plans) that involve students' use of the Internet. This link is to their index of activities, that is organized by grade level. There are a number of lesson plans about volcanoes in their Science section.

- Michigan Technological University Volcanoes Page

Michigan Tech's Volcanoes Page provides information about volcanoes to the public. Amongst these pages you will find information about current global volcanic activity, research in remote sensing of volcanoes and their eruptive products, hazard mitigation, "Decade Volcanoes", links to government agencies and research instititions, and even some volcano humour.

- Rock My World

A three-week teaching unit from the Core Knowledge Website for Grade 4 students that covers volcanoes as well as the composition of the earth, earthquakes, mountain building, Earth's surface changes, and rocks. Plenty of suggested student activities are provided within the unit.

- Stromboli Online

Stromboli is a continuously active stratovolcano situated in the Aeolian Islands between Sicily and the Italian mainland. In addition to basic information on the volcano (e.g., eruptive history, geography, maps, etc.), the site offers several virtual tours of the mountain with options for additional side trips along the way.

- Surfing for Earthquakes and Volcanoes

In this week-long lesson plan, middle school students research earthquakes and volcanoes on the Internet. Topics include: continental plate boundaries; interaction between plate boundaries; causes of earthquakes and volcanoes; and the comparison of the formation of Olympus Mons on Mars and the Hawaiian volcanic chain.

- TrackStar

TrackStar is an online interface that allows instructors to create lessons for students by sequencing existing instructional content in various Websites within a lesson. Students explore one topic at a particular location within one Website, then move on to the next topic at another Website. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the Websites beyond the designated instructional content is also possible.

This link is to their search page from where a keyword search on "volcano" will produce numerous hits. Caution #1: Many (most?) of the Websites that these lessons access will already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding Websites, sequencing the tours) will vary widely within the TrackStar collection.

United States Geological Survey

There are quite a number of resources on volcanoes within this USGS.

- Cascades Volcano Observatory
- Monitoring Active Volcanoes
- Volcanoes (on-line edition)
- Volcanoes:
- Volcanoes of the United States
- Volcano FAQs

[The] Volcanic Home Page

News, photographs, and animations of volcanoes and volcanic action are at the top of this page, but there's much more, including an extensive metalist of links to other volcano Websites, organized alphabetically.

Volcanoes

The U.S. Federal Emergency Management Agency sponsors this "FEMA for Kids" site on volcanoes. Children can learn about volcano facts, Mount St. Helens, Pele the Volcano Goddess, and disaster intensity scales.

Volcanoes and Global Climate Change

A NASA document providing information on Volcanoes and Global Cooling, Volcanoes and Ozone Depletion, and Monitoring the Effects of Volcanoes.

Volcanoes Online

A 1998 Think Quest winner, this site offers a comprehensive introduction to volcanoes and plate tectonics. In addition to explanations about the concepts, students can search their database of volcanoes or play learning games. Teachers have access to a small selection of lesson plans.

[The] Volcano Information Center

Information about volcanoes is provided by topic, including features of volcanoes, volcanic eruptions, and volcanic hazards. There are also links to other Websites for data not included with the VIC.

Volcano Trailhead aka : Tramline Volcano Field Trip

This is the starting point for a virtual field trip on volcanoes from Tramline. Experts in the subject have selected a number of Websites on volcanoes and arranged them in a sequence to tell a story for students to follow. Students can move from one Web stop in the field trip to the next with ample opportunity to explore within the individual Website as they wish. However, since their Web browser page has been split into an inner part (showing that stop in the field trip) and an outer part (giving navigational tools to go through the entire field trip), they can always return to their "tram" and go to the next stop. To be effective, teachers would have to ensure that student browsing through the field trip sites was purposeful. Teacher guides can be printed.

Volcano World

VolcanoWorld brings modern and near real time volcano information to specific target audiences and other users of the Internet. VolcanoWorld draws extensively on remote sensing images (AVHRR, Landsat TM, Magellan, Gloria, etc.) and other data collections. Value has been added to this data by relating each image to geologic processes, and by encouraging users to analyze images with provided algorithms. VolcanoWorld offers a number of lessons and activities, which students and teachers may find helpful in their quest to learn more about volanoes.

Top of Page

Note: The sites listed above will serve as a source of curricular content in Volcanoes. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

Previous Screen

Blizzard Attack!

Will you get there from here?

You are about to come face to face with a major winter storm, one that could bring you lasting memories. The kind of storm that you'll one day say to your grandchildren, "I remember that big storm...and **boy was it radical!"** Well you get the point.

Even though the experts have been tracking the storm inch by inch, as with all winter weather conditions, some unexpected and frightening changes may await you on your journey. Good luck and have a safe trip!

- Your Mission
- Sources of Weather Information
- Understanding Winter Storms
- Hit the Road

- Teacher's Guide
- Glossary of winter weather terms
- Winter Weather Safety Rules

Blizzard Attack Main Page • Expert Main Page

WeatherEye is a public service of KGAN and is sponsored by Central Iowa Power Cooperative (CIPCO). Click on Louie the Lightning Bug for electrical safety information and the Electric Universe.

"Blizzard Attack" pages created by Meteorologist Roger Evans

Igloo Builders Guide

Building an igloo is easy and fun. And the igloo is a great place to spend the night on a small 'expedition' in the mountains. Much warmer than a tent, and can be built just about anywhere. Building an igloo will take somewhere between 3 and 6 hours, depending on your previous experience and level of ambition...
This page is a small guide on building an igloo.

 Norsk versjon her.

The photos are from somewhere north-west of Hallingskarvet, Hardangervidda, Norway, and were taken in March 1992.

Equipment

The only tool needed in addition to a snow spade is a saw. A special snow saw is recommended, but a carpenter's saw will do (as seen in the pictures). A machete or small axe is handy for moulding the snow blocks, but not necessary (use your ski instead - less to carry).

Step 1: Find a suitable spot

A hard field of snow is required to build an igloo - hard enough to make solid snow blocks. Even if the top layer of snow is soft, hard snow can usually be found underneath. Use your sticks to make a circle, marking the base of the dome. The snow depth should be at least 1m where the igloo is placed. Don't make it too big, or you're into trouble later. This igloo is for 2-3 persons.

Step 2: Prepare the snow blocks

The snow blocks are prepared with the saw. They should be solid enough to be carried horisontal without breaking by their own weight. Large blocks are used at the base of the dome, smaller ones at the top. A thickness of 15-30cm is good. The blocks can be made extra strong by setting them up to harden in the wind.

Step 3: The building starts

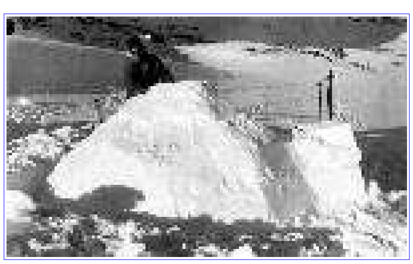
The edges of each snow block should be smoothed and angeled correctly to make a strong bond to the adjacent blocks. A ski with its tip placed in the centre of the igloo is a perfect tool for this. There will always be some (or maybe a lot of) cracks between blocks, but that is fixed later. It is very important that the bottom row of snow blocks are placed aslant, otherwise you are building a tower...

A full cricle of snow blocks has been built. Ideally, the blocks should be placed in a spiral. This will make the building easier. Note the entrance. It is made of two vertical placed blocks pointing outwards with a solid block on top to make a small roof. It might look tiny, but a lot of snow is dug out later. At this stage you might want to lower the floor inside the igloo. This way you can get 10-30cm of extra headroom!

The dome is starting to form. Keep removing the snow that is piling up inside. It is a lot easier to throw it out of an open dome than to shovel it out the entrance afterwards.

If everything is done right, the dome will not collapse because the blocks are supporting each other. But in some critical situations, you might want to use a stick inside to support the topmost blocks until the dome is closed. The last few blocks are moved into the igloo through the entrance and lifted up. There might be need of two persons inside at this stage.

Step 4: Finishing the igloo



The igloo is closed! Not a perfect dome, but good enough. Now it is time to fill all those cracks with snow. (The really big cracks are filled with small blocks of snow.) Then the inside of the igloo must be smoothed. This is done by hand (your gloves get very wet, bring extra pair!). If the inside of the dome is one, smooth surface, there will be no dripping of water at all. When the smoothing of the inside is done and all the snow has been shoveled out, it is time to finish the entrance. An L-shaped entrance is a good solution, and will prevent any snow from blowing in. First dig an L with an depth of 1m (or more), then cover it with a square 'roof' made of snow blocks. Or you can just keep the entrance simple, as shown in the image.

Its finished! This is the inside. Note how the entrance is dug deep enough to allow almost standing height (Ronny with the spade). The cold air will flow into this hollow, which function as a cold sink. *NOTE! When using a stove in the igloo, make sure the ventilation is adequate!* During cooking small holes will melt in the roof, letting fresh air in. A small ventilation hole in the roof is recommended. Always keep the entrance open. The floor should be covered with some kind of camping mattresses, Therm-a-rest or similar is a good choice. Candles can be used as light source, cut a small niche for the candle, with sufficient space above it to avoid snow melting.

Time to say goodnight (Geir in the sleeping bag). Note how the ceiling is smoothed. Even after an hours worth of cooking, there is no dripping. Actually, during the night the water that has melted will freeze again between the blocks, making the igloo stronger than ever. Next morning you might be able to stand on top of the igloo!

Well, this is it. Please excuse my spelling. If you have any comments or suggestions, mail to gedra@hate.spam.start.no Note! Remove "hate.spam." from mail address before sending.

Participants of the igloo building project:

- Ronny Finnema (master constructor)
- Geir Drange (photography, digging...)
- Anonymous (digging, carrying...)

Actually, we spent two nights in this igloo.

back home

Science Rules!

Don't Be Too Flaky

Summary: The density of water, ice, and snow aren't the same even though all three are composed of H_2O. In this experiment we'll measure the relative densities of these three substances. After you're done you can submit your results to us and they will appear here on our web site along with data contributed by other students all over the world!

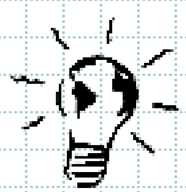
I. JUST THE FACTS

Snowflakes are formed by the freezing of water vapor in the air. Layers of snowflakes on a surface, such as the ground, are simply called snow. Snow is mostly a combination of snowflakes and air. The amount of air that snow contains affects its volume (the amount of space it takes up). When snow melts, the trapped air is released. Thus, the volume of snow is greater than the volume of the liquid water it forms when melted. Not all snow is the same, and snow is not the only form of frozen water. Ice, sleet, and hail are also mostly a combination of frozen water and air. Let's compare the properties of ice and snow around the world, and at the South Pole.

Note: if a non-metric measuring cup is used for this activity, fluid ounces can be converted to milliliters using this relationship: 1 fluid ounce = 30ml. However, strictly speaking 1 fluid ounce = 29.573730ml, but we will use the approximation of 30ml= 1 fluid ounce for this activity. Whole number estimates of other relationships between metric and English measurements are also used, such as 1 quart = 1 liter, thus 1 cup =250 ml.

II. DON'T GET HURT / WATCH OUT!

Although snow and ice are very common materials, caution should be taken to prevent possible frostbite or cuts on the hand from jagged edges of ice that may be mixed with the snow. If you use kitchen utensils in the lab, be careful to make sure that they do not come in contact with materials that will contaminate them and make them unsafe to use with food.

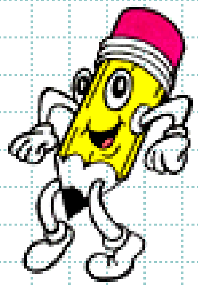


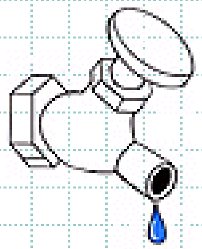
III. WHAT'S UP?

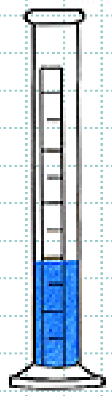
How does the volume of snow compare to the volume of liquid water that the melted snow forms?

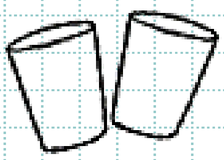
IV. WHAT DO YOU THINK?

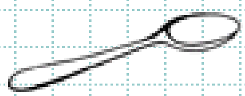
Make a guess about the amount of water you think a cup of snow will form when melted. Half as much? One-third as much? How much?

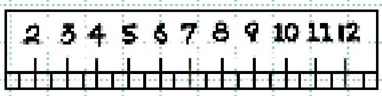












V. STUFF

- pencil
- ruler
- 1 sheet of paper
- permanent marker
- three (3) 10-oz (~300ml) clear plastic drinking cups (We suggest using 10 oz. clear plastic picnic cups that come from the same package, although other size cups will work. You need three because we will be finding average values)
- tap water
- volume measuring device (graduated cylinder or metric measuring cup 750 ml (3 cups) snow (use shaved ice, crushed ice or accumulation of frost from a home freezer as alternatives if snow is not available.)
- spoon

VI. JUST DO IT

1. Use the pencil and ruler to prepare a data table on the paper similar to the one in Scoreboard below.
2. Near the bottom edge of each cup, use the pen to label the cups A, B, and C.
3. Put 250ml (1 cup) of unpacked snow into each cup. Use the spoon to help remove the snow from the cup, but take care not to press the snow flakes together.
4. Record the volume of the snow, which should equal 250ml (1 cup), where you found it (your town, city, or locale), and a description of the snow (i.e. 3 day old snow) in the data table.
5. Draw a line and mark the snow level with an S (for snow) on each cup (all 3 should be the same).
6. Set the cups on a table indoors and allow the snow to melt.
7. When all of the snow has melted mark the water level on all three cups Sw (for snow water).
8. Pour the water from cup A into your measuring device. Record the volume of the water in the data table.
9. Determine the ratio between the volume of the snow and the volume of the water. Do this by writing a fraction with water volume as the denominator and snow volume as the numerator (ratio = Volume Snow/VolumeWater). Express the answer as a decimal by dividing the denominator into the numerator. Record the answer. (Note: the answer tells you how many time greater the snow volume is than the volume of the melted water it forms.)
10. Repeat steps 6,7 & 8 for cups B & C.
11. Determine the average ratio and record. Do this by adding the ratios and dividing by 3.

VII. SCORE BOARD

Create a table like the one below and record your data.

SNOW / WATER DATA TABLE-1

Snow Sample Location_____________________________

Description_______________________________________

SAMPLE	VOLUME (ml)		RATIO
	snow	water	snow/water
A			
B			
C			

Average Volume ratio snow/water = ______________

VIII. DO YOU SEE WHAT I SEE?

Submit the results of your experiment to us! As we collect data from students around the world we'll post the results here. To contribute your data simply fill in the blanks below and hit the "Submit" button.

Your Name: [ ]

Email Address: [ ]

Snow Sample Location: [My Town]

Description: [ ]

Average ratio snow / water: [ ]

[Send my data to Janice & Randy!] [Clear form]

Check out data already submitted. Inspect the data and answer the following questions:

1. How do your results compare with those from other areas?
2. If there is a difference, what could contribute to the difference?

IX. EXTENSIONS

If the snow were fresh would the results be different than if it were old? If you are in an area where conditions allow, wait for a new snowfall and repeat the experiment. First use fresh snow, and then repeat again using snow that has been on the ground several days (the longer the better); or repeat multiple times with a different sample every day. Prepare and record your data in a chart similar to the one shown here.

SAMPLE	VOLUME (ml)		RATIO
	snow	water	snow/water
Day 1			
Day 2			

Day 3			
Day 4			

Average Volume ratio snow/water = ______________

Home | Experiments & Activities | Q&A | Travelogue | Pictures

HOME

CARA's research and education programs are supported in part by the National Science Foundation under a cooperative agreement, grant number NSF OPP 89-20223.

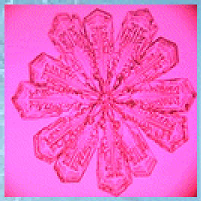
Questions? Comments? email us at caraweb@astro.uchicago.edu *Last modified Monday, 04-Dec-2000 16:35:09 CST*
http://astro.uchicago.edu/cara/southpole.edu/flaky.html

Ice and Snow

Click on the Words and Pictures Below to Explore Ice and Snow.

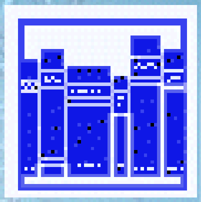
Greetings from Antarctica! Travel with researcher Diane Edwards to the coldest continent in the world and learn how to make an igloo.

Learn About Ice Find out why ice floats and why it is slippery.



Learn About Snow Learn the truth about identical snowflakes, Inuit expressions, and red snow.

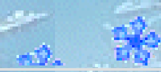
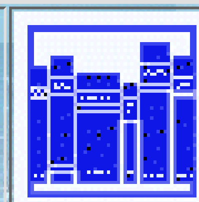
Make Your Own Flake Describe "virtual snowflakes" for different climatic conditions and see what they look like.



Further Readings A few suggested books on ice and snow.

 Back to the Dragonfly Home Page.

Look for a table like the one below on the bottom of each ice and snow page.

					
Greetings from Antarctica!	Learn About Ice	Learn About Snow	Make Your Own Flake	Further Reading	Dragonfly Home

This document was last modified on Saturday, December 13, 2003 at 17:04:14.
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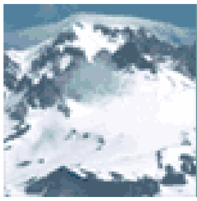
data projects research news the cryosphere

THE CRYOSPHERE WHERE THE WORLD IS FROZEN



All About Snow

Q & A Facts Glossary Gallery More snow links

All About Snow brings you, well, everything about snow.

Q & A answers the snow questions we receive. If you want to know why snow is white, or why forecasting snow can be so difficult, this is the section for you.

Facts brings together interesting bits of information we have come across in answering questions.

Use our Glossary to learn the difference between a blizzard and a squall, or to find out what graupel is.

The Snow Gallery contains historic photos of blizzards and snow from the National Weather Service.

Our Have Snow Shovel, Will Travel brochure chronicles snow removal activities in the United States.

Avalanche Awareness answers ten common questions about avalanches. The Blizzards of 1996 also answers questions, provides weather maps and images, and includes links to other notable storms. Have Snow Shovel, Will Travel describes how we have dealt with snowstorms in cities in the United States since the 1700's. Snow in the News lists the latest links to news site stories about snow.

Site Credits/More Information

Snow Links

Articles

Avalanches

Blizzards

Education

Flakes & Crystals

Lake Effect Snow

Ski & Ride

Safety

Snow Removal

Snow Science

Weather

For Scientists and Researchers

Snow Data Sites

Snow Science Sites

See Also

Avalanche Awareness

NSIDC would like to thank Nolan J. Doesken, Colorado Climate Center in the Department of Atmospheric Science at Colorado State University, and Arthur Judson. All of the definitions in the glossary, all of the facts in our fact sheet, and many of our questions and answers appear in The Snow Booklet by Doesken and Judson, U.S. Forest Service Alpine Snow and Avalanche Project, retired.

Blizzards of 1996

Have Snow Shovel, Will Travel

Snow in the News

You can order The Snow Booklet: A Guide to the Science, Climatology, and Measurement of Snow in the United States by Nolan J. Doesken and Arthur Judson (1996, ISBN #0-9651056-2-8) from the Colorado Climate Center:

Colorado Climate Center
Atmospheric Science Department
Colorado State University
Fort Collins, CO
80523-1371

All About Snow is supported in part by:

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The Blizzards of 1996

Home

Common Questions

A Closer Look at One Blizzard

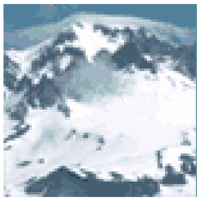
Weather Maps and Images

- January 6-8 Blizzard (Eastern U.S.)
- January 11-13 Winter Storm (Eastern U.S)
- January 17-18 Blizzard (Central U.S.)
- Legend for Weather Maps

Other Notable Storms

See also **Other Blizzard Sites**

The Blizzards of 1996 was produced in cooperation with the Network Montana Project (Montana State University) "Storm Tracking" curriculum development project. NSIDC compiled information on the blizzards and winter storms of 1996, including a selection of satellite images and surface maps for each of the storm events.



Have Snow Shovel, Will Travel

Created by Laura Cheshire. Edited by Roger G. Barry, Annette Varani, and Mike Meshek. For additional information, please contact NSIDC User Services.

Introduction

Snowstorms have historically plagued many states, notoriously those located in the Northeast and Midwest. Winter storms occur all over the country, but the "Snowbelt," stretching across the Great Lakes from Minnesota to Maine, receives the brunt of winter storms. Just as the first settlers on New England's shores struggled to survive the brutal snowstorms, so do the inhabitants of today's metropolises. Cities such as Buffalo, New York City, Milwaukee and Detroit experience snowfalls that strand residents in snow deep enough at times to be measured in feet rather than inches. Following on the heels of a severe storm in 1993, the recent paralysis experienced along the East Coast during the storms of January 1996 provides an all-too perfect example of the effect extreme winter weather can have on the nation's cities.

Officially, the National Weather Service defines a blizzard as large amounts of falling OR blowing snow with winds in excess of 35 mph and visibility of less than 1/4 of a mile for an extended period of time (greater than 3 hours). German settlers in Iowa originally coined the word blizzard, coming from the word *blitzartig*, meaning "lightning-like." European pioneers and settlers were astounded by the severity of the winters in the New World. Although accustomed to snow in their homelands, they were newly confronted with driving winds and freezing temperatures characteristic of Snowbelt regions.

Old World Settlers Combat New World Snow

Early East Coast settlements received their share of blustery storms and were battered by a series of harsh winters. Not only was the snowfall deep, but the weather was extremely cold, often freezing the bay around Boston and rivers to south as well. However, most travel was by foot, so many early storm fatalities occurred when coastal ships were caught in winter gales. Perhaps the most pressing problems for new settlers entailed shortages of wood and coal for heating homes.

As the towns grew and established routes for travel and postal service, several storms in the early

1700's rendered the roads impassable and hindered communications. A 1717 storm dumped three to four feet of snow, which in some places drifted to 25 feet. The journey from New York to Boston was almost impossible; the single successful post runner abandoned horseback for snowshoes. For over a hundred years, this storm was known as "The Great Snow." Other, less severe, snowstorms followed over the years, accompanied by the usual winter hardships. In 1741, frozen waterways and harbors resulted from a severe and very cold snowstorm, curtailing shipments along the East Coast for over a month.

Photograph of a horse drawn sleigh taken on March 18, 1888, during the Great Blizzard. (Courtesy of the Historic National Weather Service Collection.) Larger version (43k).

Although severe weather hindered commerce, residents learned from their experiences. City residents began stockpiling firewood and other supplies in advance of winter disasters. For those who couldn't afford enough wood or coal to warm their homes through the winters, several charities came to their aid. To improve travel, horse carts and coaches were installed with ski-like runners in wintertime, which were better able to handle snowy conditions than wheels. Of course, parties of revelers often took advantage of the snowy roads and ice-covered rivers, which proved excellent for sleigh rides.

Weather-watchers in rural areas and cities kept wary eyes on temperature and air pressure, and provided a climatological record as well as weather diaries for future reference. Beginning in the 1820s, they sent records to the Smithsonian Institution where the various reports were collected in an attempt to analyze and forecast weather. Reports were also relayed to the public via newspapers and telegraph dispatches.

As populations grew and commerce needs expanded, wintertime blizzards began to present more critical problems to city dwellers who relied on frequent deliveries of food and supplies. In severe winters, intercity roads and railways were often blocked for weeks at a time. Ice-jammed waterways prohibited coastal shipments as well. Fire hazards became a worsening problem, due not only to increased congestion of stoves and fireplaces, but also due sometimes to the extremely low temperatures that froze water in the tanks and hoses of the firefighting equipment.

Early Attempts at Snow Control and Removal

Early attempts at snow control simply involved citizens going into the streets to level the drifts for sleigh traffic. Ordinances in many cities required homeowners to clear their sidewalks of snow, but snow removal was not yet practiced on a citywide basis. In order for residents to travel by carriage, or for merchants to receive goods (and customers), they were responsible for clearing their own streets. Snow shovelers were frequently hire to do this for them. As a result, wintertime travel in the early 1800s was still mostly by foot.

As the 1800s progressed, new buildings and new technologies were put to the test by severe winter storms. Heavy, wet snow collapsed roofs and suspension bridges. Gale-force winds mangled telegraph and electrical lines and downed poles, increasing the threat of electrocution and electrically-sparked fires. Cities like Milwaukee, Chicago and New York responded to these new problems, enacting new codes to ensure that buildings could withstand the combined forces of snow and wind. Public officials and residents alike called for putting existing and future telegraph wires underground to avoid further safety hazards.

The Scoop on Snow Plows

Enterprising inventors were issued the first patents for snow plows in the 1840s, but several years passed before the plow designs were put to use. One of the first mentions of snow plow use comes from Milwaukee in 1862. The plow was attached to a cart pulled by a team of horses through the snow-clogged streets. Over the next several years, horse-drawn plows gained popularity and came into use in many other Northeastern cities. Intercity steam trains, having made their appearance several years earlier, now puffed and whistled their way through heavy drifts with giant plows attached to their front ends. Salt was used in a few cities, but was strongly protested because it ruined the streets for sleighing and damaged the shoes and clothing of pedestrians. However, the invention of the snow plow initiated widespread snow removal efforts in cities and also created a basis for municipal responsibility in snow removal.

Plows were a boon to city dwellers, enabling winter transportation to recover more rapidly from storms than in previous years. However, this solution was accompanied by a new round of problems, some of which remain with us today. Plowing cleared the main streets for traffic, but effectively blocked the side roads and sidewalks with huge, uneven mounds of compacted snow. Businessmen and townsfolk initially hailed the success of the plow, but later complained and even brought lawsuits against the plowing companies. Merchants claimed that their storefronts were completely blocked with mounds of plowed snow, making them inaccessible to their customers, and pedestrians bemoaned trying to negotiate the huge mounds which often obstructed the sidewalks. Sleigh drivers also found fault with the plowing system because of the ruts and uneven surfaces it created.

New York and other cities responded in several ways. They hired horse-drawn carts and shovelers to work in conjunction with the plows, hauling away the plowed snow and dumping it into rivers. This not only cleared the mounds of snow, but provided thousands of temporary jobs throughout the winter season. In an effort to curtail the use of salt, which many still protested, streets and icy bridges were coated with sand instead. To appease all sides, New York in the 1880s built elevated steam railways along the major routes of the city, high enough that they would not be affected by the drifts. Still in operation today, these elevated tracks proved very successful, and carried travelers through all but a few of the most severe storms. Prior to the invention of the subway, the elevated trains were often the only transport service available in storms that halted all ground travel.

The Blizzard of 1888

In spite of these advances in their struggle against snow, the notorious "Blizzard of 1888" literally paralyzed the Northeast after three days of snow, wind and freezing temperatures. Two-and-a-half to four feet of snow fell, and drifts were reported to cover entire first stories of buildings. Carts and carriages in the streets were abandoned and buried by snow as drivers realized the futility of their endeavors. Schools, city railroads and public offices were closed, and even New York's elevated railways were victim to the mounting drifts. A mile's worth of passenger trains headed for New York were trapped for two days in drifts exceeding 20 feet. Tragically, over 400 people lost their lives in this storm.

Following the 1888 blizzard, cities recognized the need for more organized snow removal and looked for ways to avoid some problems altogether. Previously, city officials often waited until storms were nearly over to begin snow removal, but now realized that taking action during the first stages of a storm produced better results and more rapidly cleared roads. To combat the snow more effectively, cities were divided into sections and assigned to plow drivers. Increased numbers of plows cleared the streets with more efficiency. Driven by the ferocity of that blizzard, city officials were also more determined to bury communication wires and create alternative methods of transportation, such as trains and subways, that wouldn't be hindered by drifting snow.

The Great Blizzard of March 12, 1888. New York, New York. (Courtesy of the Historic National Weather Service Collection.) Larger version (43k).

Steam trains were fairly effective at clearing their own tracks when equipped with plows. However, for shorter inner-city transport, cities tried electric trolleys with plows, which proved to be unsuccessful. Several northeastern cities had long toyed with the idea of underground railways, but in the wake of the blizzard, it was an idea whose time had come. Boston installed the first stretch of subway tracks in 1899. New York followed with its own subway five years later, and both cities extended their lines significantly over time.

Snowstorms in the Wild West

Cleared train tracks in the Sierra Nevada at Emigrant Gap, California, after a snow storm in 1917. (Courtesy of the Historic National Weather Service Collection.) Larger version (36k).

While some of the snowiest places in the West were (and still are) in remote, relatively uninhabited places, there were incidents of travelers getting caught in winter storms, often with grim consequences. In October 1846, at the beginning of what is still considered to be a record snow season, George Donner, leading a group across the Truckee Pass, just north of Tahoe City, California was surprised by an early winter blizzard. Within eight days, forty-foot drifts had accumulated, trapping the group in the mountains. They weren't rescued until April 1847, and by then only 47 of the initial 87 remained alive amid reports of cannibalism. In winter 1873, Alferd Packer and several other gold seekers trekked into the San Juan Mountains of southern Colorado. Trapped in severe winter weather, months later, only Packer returned. When the bodies of the remaining men were found, evidence indicated that they had been cannibalized by Packer, for which he was tried and convicted.

Although the sparsely populated West was not as drastically affected as the eastern metropolises, the western states also received a fair share of winter storms. In the western part of the country railroads provided a significant source of transportation especially for the mountain mining industries. Subways and elevated rails were just not practical for the vast plains and mountain passes, so steam trains battled drifts with giant rotary plows, plowing snow and blowing it away at the same time. Ranchers erected snow fences, which protected roads and prevented snow from drifting too high on their property. The burgeoning population centers of the West, such as Denver, Salt Lake City, and Seattle, soon acquired snow removal equipment to battle the winter storms. However, they were often able to rely on the sun or mild weather to melt heavy snowfalls, as they still do today.

Planes, Lanes, and Automobiles

Motorization swept the country with amazing speed in the early 20th century, leading to motorized dump trucks and plows as early as 1913. Many cities rushed to motorize their snow removal fleets, abandoning most of their horse-drawn carts. In conjunction with the new trucks, cities began to use Caterpillar tractors equipped with plow blades. To haul the snow away, they used steam shovels, cranes, and railway flatcars to get the snow off the streets and dumped into the rivers. In spite of the technological advances, manual shovelers also continued to be hired as part of the winter work force.

Another motorized invention, the Barber-Green snowloader, was successfully tried in Chicago in 1920, and several cities purchased snowloaders that same winter. The snowloader was an ingenious contraption. Riding on tractor treads, it was equipped with a giant scoop and a conveyor belt. As the snow was plowed, it was forced up the scoop, caught by the conveyor belt which carried it up and away from the street into a chute at the top where it was dropped into a dump truck parked underneath. It effectively made snow removal easier and more effective for the cities by making the process much less labor and time intensive.

Early aviation development also advanced the snow removal technology. Runways needed to be kept especially clear, prompting the first small airports to find solutions. Salt was effective only on ice and light snowfalls, and plowing mounds of heavy snow was time-consuming. To combat the snow even before it hit the ground, snow fences were constructed on the windward sides of the runways, effectively trapping snow and preventing it from blowing onto the runways. Light snow dustings were simpler to control.

New fleets of dump trucks and tractor plows were very expensive for cities to purchase and maintain, but the amount of revenue lost if the streets were not cleared was by far more expensive than snow removal equipment. As cities and businesses provided urban populations with a wide variety of goods and services on a daily basis, they were struck a financial blow when a large snowfall debilitated transportation and prohibited customers from reaching them.

New Winter Problems for Cities

It was in fact the popularity of the motorcar that would create a whole new set of problems for snow removal crews. By 1925, over seventeen million cars were registered, vastly increasing the demand for dry, safe streets. As motorcars took to the streets in force, public safety demanded snow removal efforts even for snowfalls less than four inches. Due to increased dependence on the automobile, not only main thoroughfares needed clearing, but residential streets as well. Scenic snowfalls once reminiscent of winter merrymaking became unbearable, and the freezing weather once welcomed by sleigh parties create hazardous driving conditions. Automobile accidents were rapidly rising due to weather-related conditions.

An aerial view of an expressway in Chicago, paralyzed after a blizzard, January 26-27, 1967. (Courtesy of the Historical National Weather Service Collection.) Larger version (44k).

Slick layers of ice left behind by snow plowing, renewed demands for salt and sand use. No longer concerned about protests, city public works officials used salt by the ton to ease road conditions, and also experimented with cinders and sand. Motorized salt spreaders became the primary tool in fighting snowy roads, and businesses and private citizens as well used tons of salt to keep driveways, sidewalks and access routes clear of snow and ice. However, several cities in the Great

Lakes region were unable to use salt due to the extremely frigid weather that rendered salt almost ineffective. In any city, while salt works well on icy roads or minimal snowfall, it does little good against deep snow.

Parked and abandoned vehicles posed the other great problem faced by snow removal crews. Urban streets now provided parking places, which in winter months hampered snowplowing efforts. Desperately needing to clear the streets, plows ended up packing huge, compacted drifts against parked cars, forcing unwary owners to dig them out. Realizing there was a conflict, city ordinances were created, banning overnight parking for certain city areas, or posting signs marking snow plow routes, where parking would be banned when plows were in use. Many of these ordinances are still in effect throughout major cities, increasing the efficiency and thoroughness of plowing efforts.

Along highways, severe blizzards stranded motorists who often abandoned their vehicles, creating nightmares for plowing crews who tried to clear around lumps of snow-covered cars. Conceding defeat, snow removal efforts in this case were (and still are) forced to tip their hats to Mother Nature. Today, winter weather still catches commuters unprepared, and inevitably highways become littered with stalled and abandoned cars during blizzards. As in the storm of 1996 that paralyzed the East Coast, several states have required federal assistance from time to time, in the form of financial aid and the aid of National Guard troops to clear streets and help remove cars from highways.

Snowy Challenges and New Technology

Well after automobile use had become widespread, shopping centers, office parks and industrial centers saw the need for private snow removal equipment of their own to clear parking lots for their employees and customers. This created a market for smaller, customized equipment, and spurred technology to develop more specialized functions. Smaller plows and snow blowers were also in growing demand by private residents who sought to escape the rigors of the old-fashioned snow shovel.

In 1959, space technology entered the snow removal effort, and satellites observed and relayed climate and weather conditions, allowing for more accurate storm forecasting. While attempts at forecasting had been made earlier through weather-watchers using telegraphs, phones, and radios to communicate, this system could not be relied on with nearly as much accuracy. Cities were able to brace themselves in advance for severe winter weather and prepare for snow removal efforts. Also, increased use of media such as radio and television helped keep the public aware of impeding hazardous situations. Most of us realize how critical this has proven in our own lives, as many of us have been able to change or curtail our plans due to televised weather forecasts warning us of incoming storms, potential snowfall amounts, temperatures and wind chill factors.

As snow removal efforts progressed, protests against salt renewed, supported both by environmentalists and motorists whose cars were being corroded by years of heavy winter salt use. Environmental experts discovered in the late 1960s that salt use was corroding cars, damaging roadside plant life, polluting water supplies (including drinking water supplies), and killing fish in streams. Motorists were weary of repairing car corrosion after each winter, and road crews were discovering that salt was corrosive to roads and bridges as well. Improved salt spreaders resulted from these finds, using more efficient spreading gauges.

Recent Wintertime Problems

Heavy winds and blowing snow wreak havoc on traffic and roads. A truck with a snow plow attachment clears a road in this photograph from November 10, 1998. (Courtesy of the National Renewable Energy Laboratory and the Department of Energy. Photograph by David Parsons.) Larger version (32k).

Within the past twenty years, cities have been met with new problems, often results of solutions to previous problems. For instance, weather reports conveniently forewarn people of incoming storms and deep-freezes. Unfortunately, this often leads to careless judgments; thinking they can outrun a storm, people become stranded at stores or in traffic when the blizzard hits in force. Not only is this frustrating for those wishing to get home, but the resulting traffic jams also impede plowing efforts. Several cities have needed to call states of emergency, and restrict driving to only emergency cases.

One of the less obvious problems faced by cities is the high cost of snow removal. For instance, costs in Montreal, Canada, exceed sixty million dollars per season. There, up to two thousand workers operate vehicles and spread salt to clear the streets. While each city will vary in what type of equipment and what it needs to spend, snow removal has become a large factor in annual city budgets. Cities like Denver and Salt Lake can rely on sunshine to melt the piles of snow left along the sides of streets after plowing. Northeastern and Snowbelt cities, however, need to account for not only plowing and salting, but hauling the snow away since it may not melt rapidly enough. On top of this, each season brings new surprises; a winter with mild temperatures and little snowfall may be followed by a winter with several severe snowstorms.

Another recent problem is that of driver carelessness. Drivers should take extra precautions when driving in each new storm, even after roads have been salted or plowed. In congested city traffic defensive driving becomes critical during inclement weather. While four wheel drive vehicles have received criticism for the false sense of security they provide, they have become a necessity for mountain residents, offering better traction and handling on snow-packed roads. Motorists need to be completely aware of road conditions (icy, slushy, snowpacked, etc.). They should keep in mind any possible hazards and plan in advance for them. Motorists need to choose alternate routes when inclement weather makes normal routes treacherous and leave enough time to account for slower driving speeds and possible traffic jams. Carrying sacks of sand or kitty litter comes in handy to spread on slick spots. Those living in remote areas might want to keep spare equipment in their car or truck, such as shovels, flashlight, matches, blankets, spare clothes, food and water, in the event of becoming stranded in a storm.

Safety in Snowstorms

You may not be able to avoid living in a snowstorm prone region, but there are ways you can avoid becoming a victim of blizzards and winter storms. Stay inside if you are home, and except for emergencies, don't leave until the storm has abated. Deaths are often caused indirectly by storms, due to traffic accidents and hypothermia (caused by overexposure to cold weather). While shoveling snow, be sure to take frequent breaks. This will not only help your sore muscles, but may also prevent any chance of a heart attack, which can be triggered by rigorous shoveling. It is ideal to stock your house even before winter begins, with non-perishable food, medicine, bottled water, baby items, wood, batteries, matches and candles. Blizzards are notorious for defying weather forecasts and arriving early, so don't wait until the day or morning before a blizzard is expected to strike to stock up on essential supplies.

If you are caught in a storm and your vehicle is immobilized, remain in or near your car or truck unless you can see a source of help. You may want to get out and clear the exhaust pipe to prevent possibility of carbon monoxide poisoning. Also, set flares, tie a bright piece of cloth to the antenna, or raise the hood of your car to make yourself visible and increase your chance for rescue. Once you have done this, get back in your vehicle and remain inside. Crack a window for ventilation. Turn on the engine for ten or fifteen minutes every hour for heat, and try to keep your blood circulating by exercising from time to time, moving arms, legs, fingers and toes.

The Blizzard of 1996

In January, the "Blizzard of 1996" hit the southeastern states and worked its way up to the northeastern states, claiming over 100 lives and forcing nine northeastern and southern states to declare a state of emergency. Snowfall amounts ranged from one to four feet, with Virginia and West Virginia hit the hardest. Several states made nonemergency driving illegal, and most major airports were closed for at least a day or two, canceling thousands of flights.

A week later, while many cities were still digging out, two new storms struck the Eastern Seaboard, bringing up to a foot of additional snow. Around New York City, a church roof and two store roofs collapsed from the added weight of the new snow. For several days afterwards, many travelers were forced to trudge long distances through hip-deep snow to get to subway and train stations, as not all roads had been adequately cleared for busses or cars.

Approximate state snowfall amounts

Virginia	48 inches
West Virginia	43 inches
Maryland	33 inches
Pennsylvania	30 inches
New Jersey	28 inches
New York	28 inches
Connecticut	27 inches
Kentucky	27 inches
North Carolina	25 inches
District of Columbia	24 inches
Ohio	17 inches
Massachusetts	17 inches
Georgia	12 inches

City snowfall records

Philadelphia, PA	30 inches
Newark, NJ	28 inches
New York, NY	20 inches
Charleston, WV	19 inches
Cincinnati, OH	14 inches

Please see our Blizzard of 1996 pages.

Mother Nature continues to best our human endeavors. A 1958 New York report stated that rain was falling on the ground, yet guards were making snowballs atop the 1150 foot Empire State Building. The winter of 1977 proved especially harsh worldwide. In Buffalo, New York, snow drifts were so compacted by wind that plow blades broke trying to clear them, and halfway across the world in Japan, record heavy snows collapsed over 200 roofs. Arctic weather dipped to the southernmost part of the United States in 1985, blanketing San Antonio with 13 inches of snow, and dusting several other southern cities with snow as well. On March 13, 1993, the "White Hurricane" pummeled the entire eastern seaboard, resulting in 92 deaths. Syracuse and Boston broke snowfall records that year, and New York city struggled with snow and ice for two weeks after the storm. No doubt the Blizzard of '96 will top records across the Northeast once again. And, as recent pleas for snow shovelers testify, the good old-fashioned snow shovel continues to be one of the most effective, time-honored tool for digging out our nation's cities.

The Snowiest Cities in the Country

Snowbelt cities dominate the list, but others, such as Denver, Salt Lake City, Omaha and Seattle also receive significant amounts of snowfall. Buffalo maintains the all-time high for snowfall in a single season, holding the record at 199 inches, all of which accumulated during the 1976/77 winter. Rochester, New York, comes in second, with 161 inches in a season, and Portland, Maine, comes in third with 141 inches in a single season. These three cities also carry some of the highest monthly totals in snowfall as well. The recent Blizzard of 1996 may help topple a few seasonal snowfall records.

Paradise Inn, Mount Rainier, Washington. During the winter of 1916-1917, 789.5 inches of snow fell at Paradise Inn. When this photo was taken, in March 1917, the snow was 27 feet deep. (Courtesy of Historic National Weather Service Collection.) Larger version (35k).

In the Midwest and West, Salt Lake City, Utah, Anchorage, Alaska, and Denver, Colorado, have each received around a 100 inches or more in their record high seasons. These record highs are for cities only; however, remote mountain areas and smaller towns have received higher snowfall amounts. Paradise Ranger Station in Washington State has received over 1000 inches (or 85 feet) of snow in a single season. Sites along the Rocky Mountains and Sierra Nevada Mountains also receive between 400 and 800 inches (or 33 to 66 feet) in a season.

Some Notable Snowstorms

February and March 1717: "The Great Snow of 1717" blanketed New England in a series of four storms, leaving nearly four feet on the ground and drifts up to 25 feet high.

January 1772: "The Washington and Jefferson Snowstorm" is so named because it trapped both men at their homes with snow up to three feet deep throughout Maryland and Virginia.

December 1778: Named after the Revolutionary War troops stationed in Rhode Island, drifts were reported to be 15 feet high after this storm.

November 1798: "The Long Storm" went down in history as the snowiest on record for that month. Stretching from Maryland to Maine, up to a foot-and-a-half of snow coated the region.

December 1811: A powerful storm buffeted New York City, Long Island, and southern New England, accompanied by gale-force winds and destructive tides that severely damaged many ships and harbors.

January 1857: "The Cold Storm" produced severe blizzard conditions along much of the eastern seaboard. Temperatures fell below 9 below zero Fahrenheit, and snowfalls were between one and two feet deep.

March 1888: The "Blizzard of '88" produced temperatures plummeting well below zero degrees Fahrenheit, ravaging gusts of wind and deep snow drifts that stranded several cities, leaving them without transportation or communication. New York City suffered the most damage, particularly to its harbor areas.

November 1898: The "Portland Storm" was named after the ship that sank off the coast of Cape Cod, the S.S. Portland. High winds and moderately heavy snows accompanied the storm.

January 1922: The "Knickerbocker Storm" dumped over two feet of heavy snow on Washington D.C. causing the roof of the Knickerbocker Theatre to collapse, killing nearly 100 people.

December 1947: A post-Christmas storm caught New York residents by surprise, dropping two feet of snow in 24 hours.

January 1967: A series of record-breaking storms battered the west coast of Lake Michigan, hitting Chicago the hardest, shutting nearly everything down. Looting of the unattended stores became rampant, and it took the city over two weeks to clear the major highways and roads.

February 1969: New York City became trapped under a foot-and-a-half of snow. Commuters became stranded in their cars, schools closed, and travelers were stuck at airports, which were also forced to close. To make matters worse, many of the snow plows had become buried by snow in their storage lots and had to be dug out before they could be used. The city and outlying suburbs were forced to hire 10,000 shovelers and workers to clear the streets.

February 1977: Ontario, Canada and western New York state were slammed by a storm that killed 28 people and shut down the city of

Buffalo for over a week. Highways were clogged with thousands of stranded vehicles, and people became trapped at schools, stores and offices, where they were forced to spend the night because they could not make it home through the blizzard.

March 1993: The "Blizzard of the Century" ravaged the southern mid-Atlantic states from Alabama to Massachusetts, accompanied in other states by severe weather disturbances such as tornadoes, thunderstorms, and floods. Snow fell at rates between an inch and two inches an hour in some areas, and many locations experienced record-breaking snowfalls and record snow depths.

Even states in the southern part of the United States can get significant amounts of snow. This photo was taken in Bull Shoals, Arkansas, after the Blizzard of '93. (Courtesy of the Historic National Weather Service Collection. Photography by Elizabeth A. Hobbs.) Larger version (40k).

January 1996: The Blizzard of 1996 was responsible for over 100 deaths and brought much of the eastern United States to a complete halt. Schools, offices and airports were closed for several days in some areas as roads were impassable. Compounding problems, two subsequent storms blasted the same areas within the following week-and-a-half.

Want to Know More about Snow?

Look for these sources in your library!

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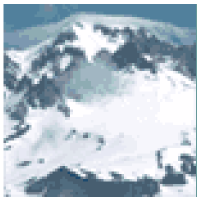

Snow Facts

- Snow continues to challenge weather experts across the country. It is still very difficult to predict and is surprisingly hard to measure once it has fallen.
- Based on National Weather Service records for 1961 through 1990, Rochester, New York averages 94 inches of snow annually and is the snowiest large city in the United States. Rochester has a population more than 200,000 and annual municipal snow-removal budget of $3.7 million (1995 figures).
- Buffalo, New York, is a close runner-up in terms of U.S. large cities with the most snow. A 39-inch snowfall in 24 hours in early December 1995 cost the city nearly $5 million for snow removal.
- Almost 187 inches of snow fell in seven days on Thompson Pass, Alaska in February, 1953, according to the [National Snowfall and Snow Depth Extremes Table](#) provided by the [National Climatic Data Center](#).
- Each year an average of 105 snow-producing storms affect the continental United States. A typical storm will have a snow-producing lifetime of two to five days and will bring snow to portions of several states.
- In the early 1900s, skiers created their own terminology to describe types of snow, including the terms "fluffy snow," "powder snow," and "sticky snow." Later, the terminology expanded to include descriptive terms such as "champagne powder," "corduroy," and "mashed potatoes."

- Fresh snow is an excellent insulator. Ten inches of fresh snow with a density of 0.07 inches, seven percent water, is approximately equal to a six-inch-layer of fiberglass insulation with an insulation R-value of R-18.

- Practically every location in the United States has seen snowfall. Even most portions of southern Florida have seen a few snow flurries.

- Snow kills hundreds of people in the United States each year. The primary snow-related deaths are from traffic accidents, overexertion, and exposure, but deaths from avalanches have been steadily increasing.

- The greatest snowfall officially reported at the Phoenix, Arizona National Weather Service Office was one inch. That occurred twice. The first time was January 20, 1933. It happened again four years later on the same date.

- In the western United States, mountain snow pack contributes up to 75 percent of all year-round surface water supplies.

- The commonly used ten-to-one ratio of snowfall to water content is a myth for much of the United States. This ration varies from as low as 100-to-one to as high as about three-to-one depending on the meteorological conditions associated with the snowfall.

- Nationwide, the average snowfall amount per day when snow falls is about two inches, but in some mountain areas of the West, an average of seven inches per snow day is observed.

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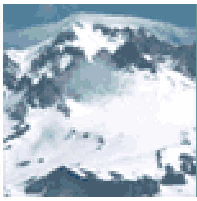

All About Snow

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Snow Glossary

ablation	the process of being removed. Snow ablation usually refers to removal by melting
accretion	growth of precipitation particles by collision of ice crystals with supercooled liquid droplets which freeze on impact
blizzard	winds of at least 35 miles per hour along with considerable falling and/or blowing snow reducing visibility to less than one-quarter mile for a period of at least three hours. (xtremely cold temperatures often are associated with dangerous blizzard conditions, but are not a formal part of the modern definition.)
climatology	the science and study of climate; the aggregate of all weather conditions at a point over a long period of time
condensation	the process in which water vapor becomes liquid
dendrite	hexagonal ice crystals with complex and often fernlike branches.
depth hoar	large (one to several millimeters in diameter), cohesionless, coarse, faceted snow crystals which result from the presence of strong temperature gradients within the snowpack
evaporation (water)	the physical process in which liquid water changes into a gas
firn	rounded, well-bonded snow that is older than one year

graupel	snowflakes that become rounded pellets due to riming. Typical sizes are two to five millimeters in diameter (0.1 to 0.2 inches). Graupel is sometimes mistaken for hail.
metamorphism	changes in the structure and texture of snow grains which results from variations in temperature, migration of liquid water and water vapor, and pressure within the snow cover
precipitation	the accumulated depth of rain or drizzle and also the melted water content of snow or other forms of frozen precipitation, including hail
polycrystal	a snowflake composed of many individual ice crystals
rime	a deposit of ice formed when supercooled water droplets freeze on contact with an object
saturation vapor pressure (water)	the maximum amount of water vapor necessary to keep moist air in equilibrium with a surface of pure water. This is the maximum water vapor the air can hold for any given combination of temperature and pressure
snowboard	a solid, flat, white material, such as painted plywood, approximately two feet on each side, that is laid on the ground or on the surface of the snow by weather observers to obtain more accurate measurements of snowfall and water content
snow core	a sample of snow, either just the freshly fallen snow or the combined old and new snow on the ground, obtained by pushing a cylinder down through the snow layer and extracting it
snowbursts	very intense showers of snow, often of short duration, that greatly restrict visibility and produce periods of rapid snow accumulation
snow density	the mass of snow per unit volume which is equal to the water content of snow divided by its depth
snowfall	the depth of new snow that has accumulated since the previous day or since the previous observation
snow depth	the combined total depth of both old and new snow on the ground
snowflake	a cluster of ice crystals that falls from a cloud
snow flurries	snow that falls for short durations and which often changes in intensity. Flurries usually produce little accumulation

snow load	the downward force on an object or structure caused by the weight of accumulated snow
snow water equivalent	the water content obtained from melting
snowpack	the total snow and ice on the ground, including both new snow and the previous snow and ice which has not melted
snow squall	a brief, but intense fall of snow that greatly reduces visibility and which is often accompanied by strong winds
sublimation	the process in which ice changes directly to water vapor without melting, but also in meteorology the opposite process in which water vapor is transformed to ice (also called deposition)
supercooled	the condition when a liquid remains in the liquid state even through its temperature is below its freezing point
supersaturation	the condition which occurs in the atmosphere when the relative humidity is greater than 100 percent
surface hoar	the deposition (sublimation) of ice crystals on a surface which occurs when the temperature of the surface is colder than the air above and colder than the frost point of that air
vapor pressure	the pressure exerted by water vapor molecules in a given volume of air

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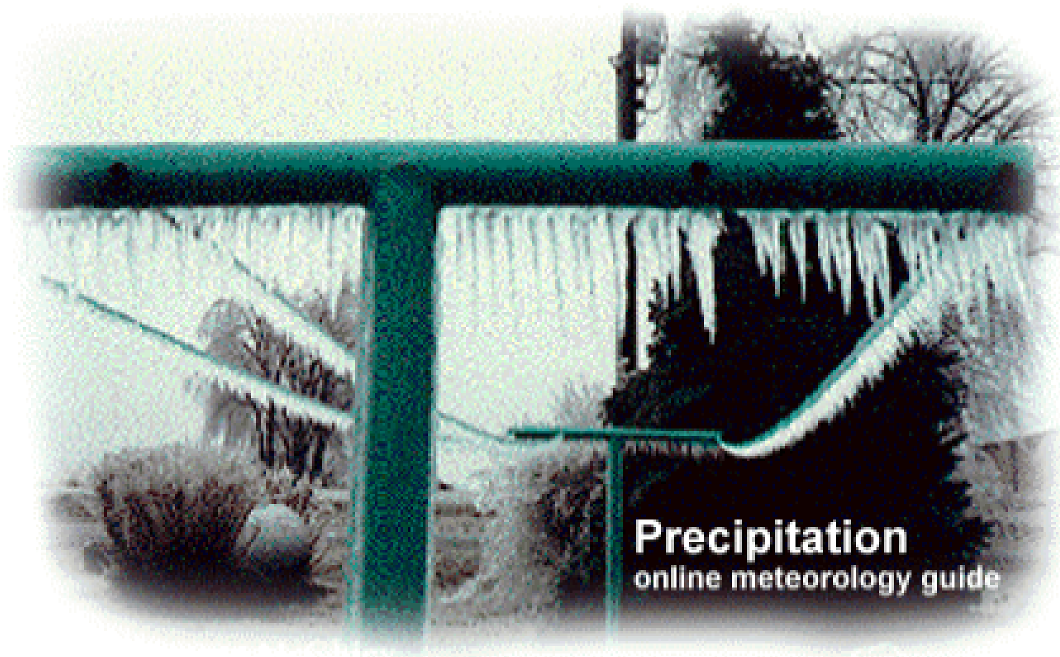
Clouds, Precipitation
- introduction
- development
- cloud types
- precipitation

Precipitation
- introduction
- rain and hail
- freezing rain
- sleet
- snow

User Interface
- graphics
- text



Photograph by: Norene McGhiey

When cloud particles become too heavy to remain suspended in the air, they fall to the earth as precipitation. Precipitation occurs in a variety of forms; hail, rain, freezing rain, sleet or snow. This portion of the Clouds and Precipitation module focuses on precipitation and has been organized into the following sections.

Sections

Latest Update: 07/21/97

Rain and Hail
Atmospheric conditions that lead to the development of rain and hail.

Freezing Rain
A detailed look at freezing rain, associated dangers and the conditions that lead to its development.

Sleet
Atmospheric conditions that lead to the development of sleet.

Snow
Atmospheric conditions that lead to the development of snow.

Acknowledgments
Those who contributed to the Precipitation sections of the Clouds and Precipitation module.

The navigation menu (left) for this section is called "Precipitation" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Other Cloud Types

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

rain and hail

SNOW

Here you can learn the basics of the snow.

Build your own snow castle or look famous snow castles.

Make virtual snow flakes.

Experiment the excitement of the snowball fight.

Become a snow artist. Make snowmen, snow lanterns or snow sculptures.

Look our amazing snow links.

Send Your comments to us!

NetworkSolutions®

This Site is Under Construction and Coming Soon.

Sponsored Links

Find Relatives
Search Free All records $10 flat fee
www.PeopleData.com

Genealogy
Instant National Public Records. Browse Our Huge & Accurate database
www.Intelius.com

Find old friends
Have a reunion with old friends family and school mates aff
www.reunion.com

Build your Family Tree
Everything you need to build your Family Tree. Join Today Aff
www.genealogy.com

Find Your Genealogy
Search the U.S. Census Collection More Reliable & Comprehensive!
Ancestry.com

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Family genealogy	Minnesota genealogy
Family travel	Iowa genealogy
Genealogie	Georgia genealogy
Family records	Oklahoma genealogy
Geneaology	Mother
Irish genealogy	Ancestry
Family adventure	New york genealogy
Family histories	Louisiana genealogy
Genealogical	Washington genealogy
Genealogies	Kentucky genealogy
Parenting	Kansas genealogy

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Alt Text

Build Your Business:

Get listed in top search engines
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Forward visitors to your web site
Incorporate Your Business

Other Popular Categories

Travel	Financial Planning	Business and Finance	Health and Beauty	Health Products
Car Rental	Debt	Affiliate Program	Skin Care Products	Vitamins
Hotels	Credit Cards	Student Loans	Exercise Equipment	Weight Loss Drugs
Airline	Loans	Stocks	Hair Replacement	Joint Pain Relief

Try a Search: Go!

Alt Text

Trademark Free Zone, Review our Privacy Policy, Service Agreement, Legal Notice

This site is even better in Flash. Download the Flash Player now.

Sorry, but we're having a little trouble finding what you were looking for.

Are you doing some student research?

We did a lot of reorganizing recently to try to make things easier to find. Unfortunately, it looks like whatever you are looking for has found a new hiding place. Try the main category links above or start from our Home Page. If you still cannot find it on your own, please let us know and we'll try to help you out.

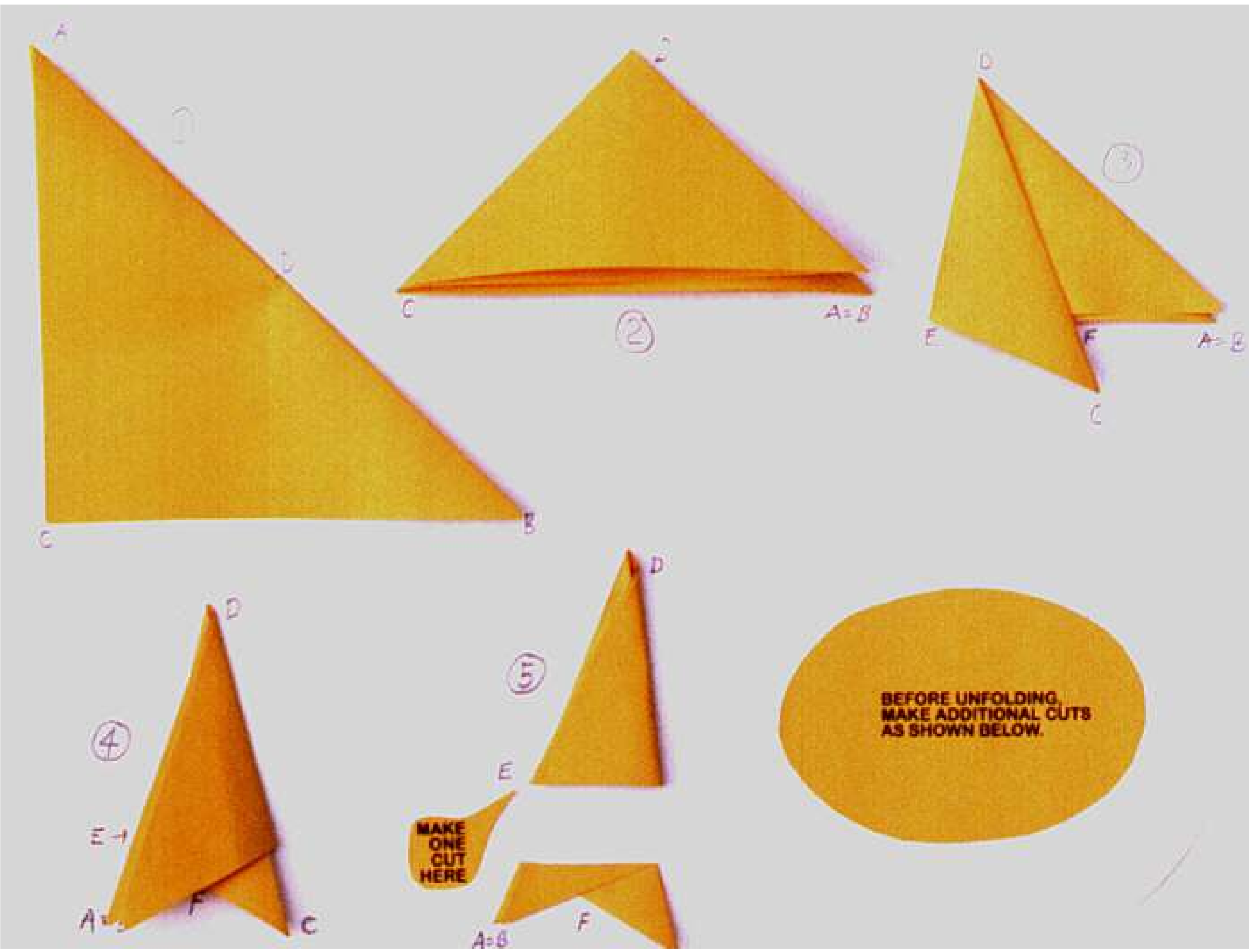
We re guessing you may have been looking for something in our Winter Holidays section.

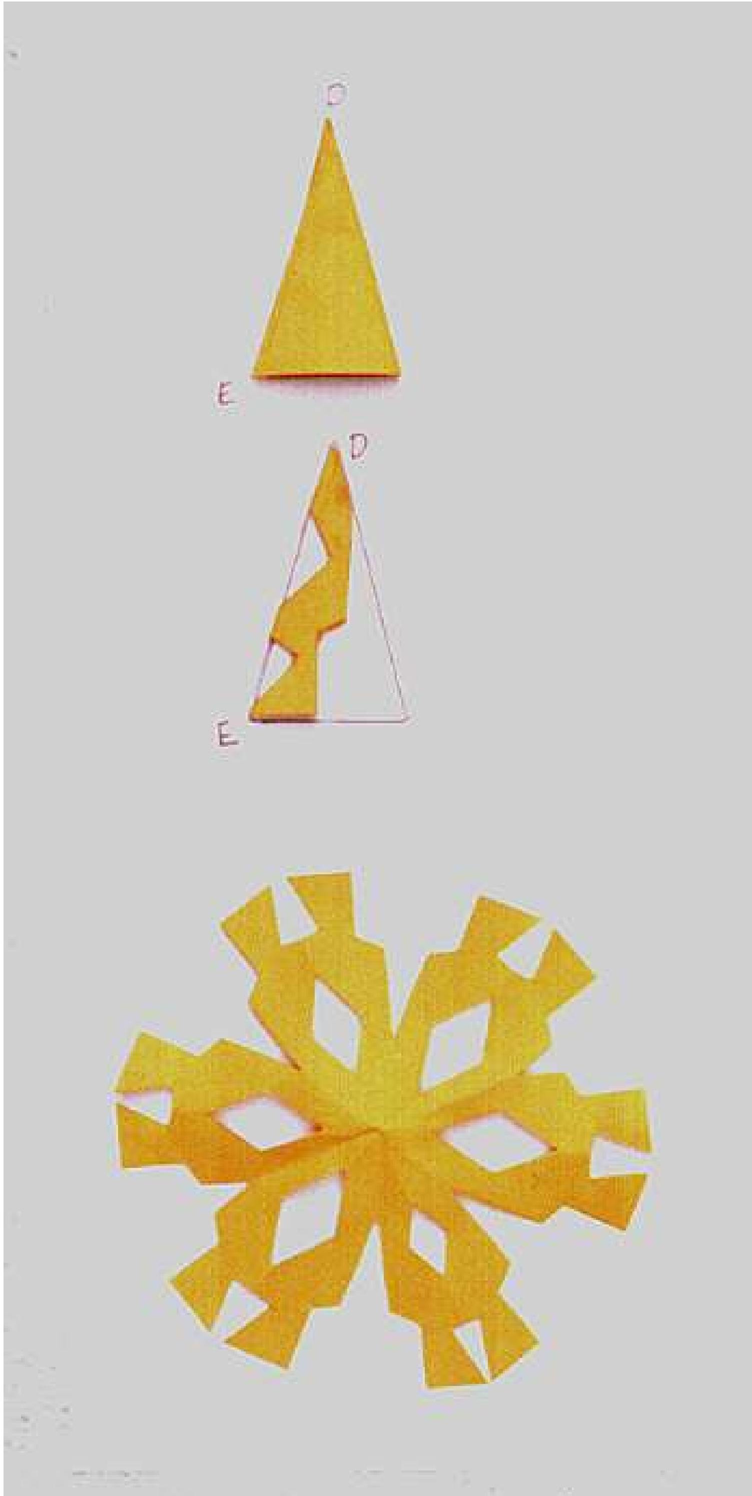
Home | Our Company | Our Products | Scoop Shops | Fun Stuff | Gift Shop
International | Contact Us | Terms of Use | Privacy
Sign up for ChunkMail

30 Community Drive
South Burlington, VT 05403-6828

Paper Snowflakes

Below is a diagram of the first five steps to make a paper snowflake. (If you have made the [6 - Point Star - Paper Relief] these are the same five steps except in the last step the cut is made as shown below.) Begin with a square sheet of paper and in the first step, fold it on the diagonal. Continue through the other steps.

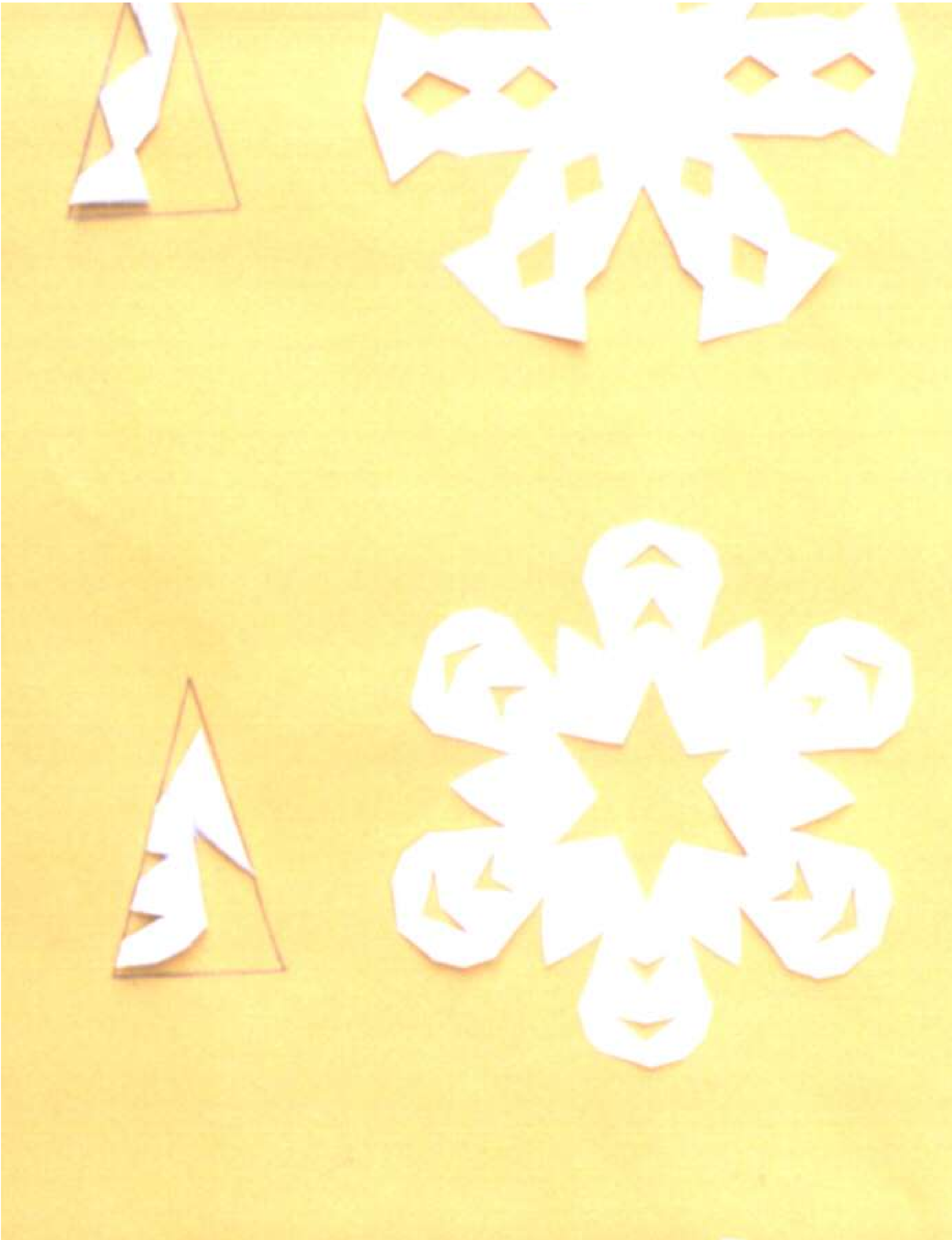


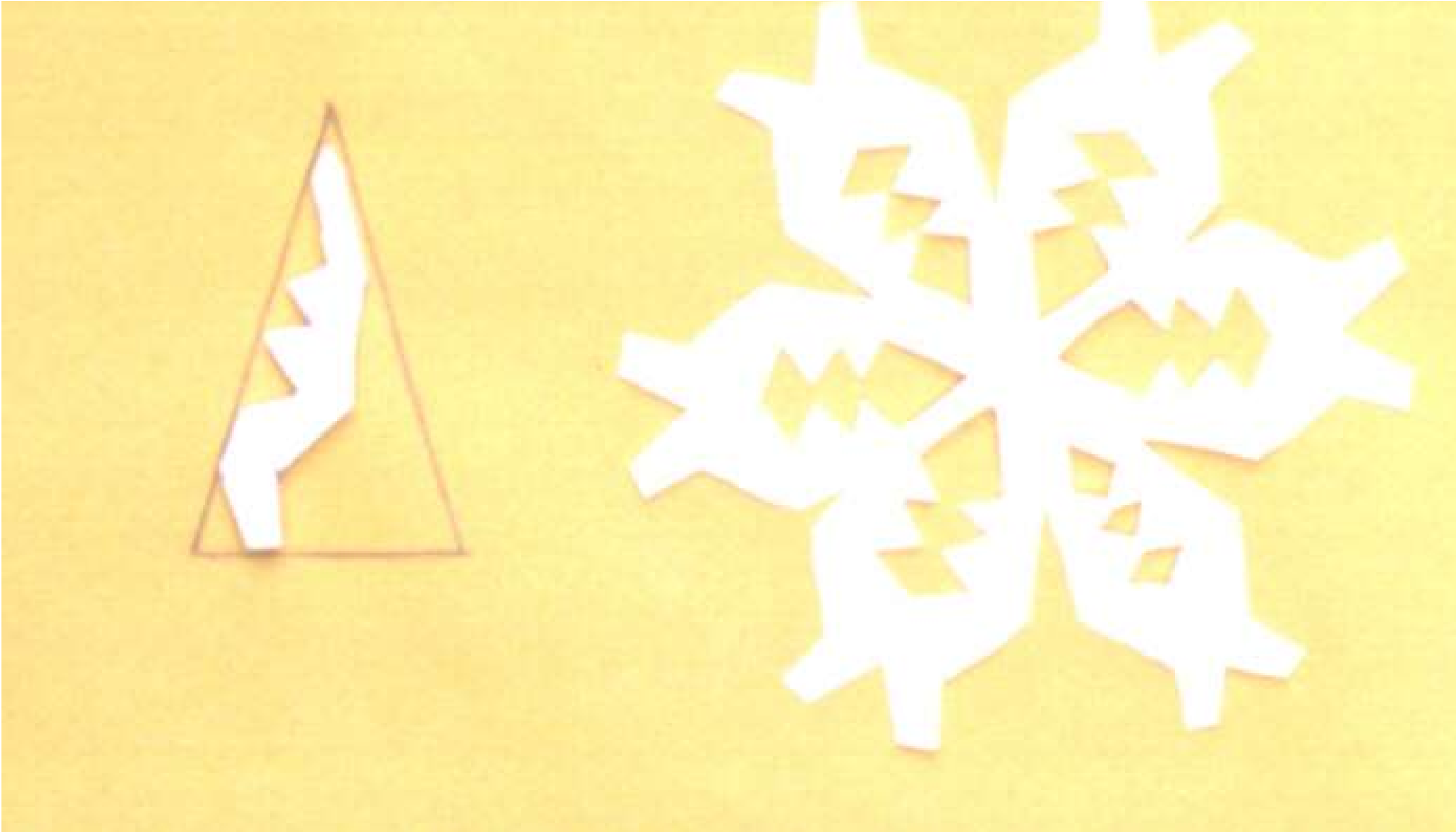


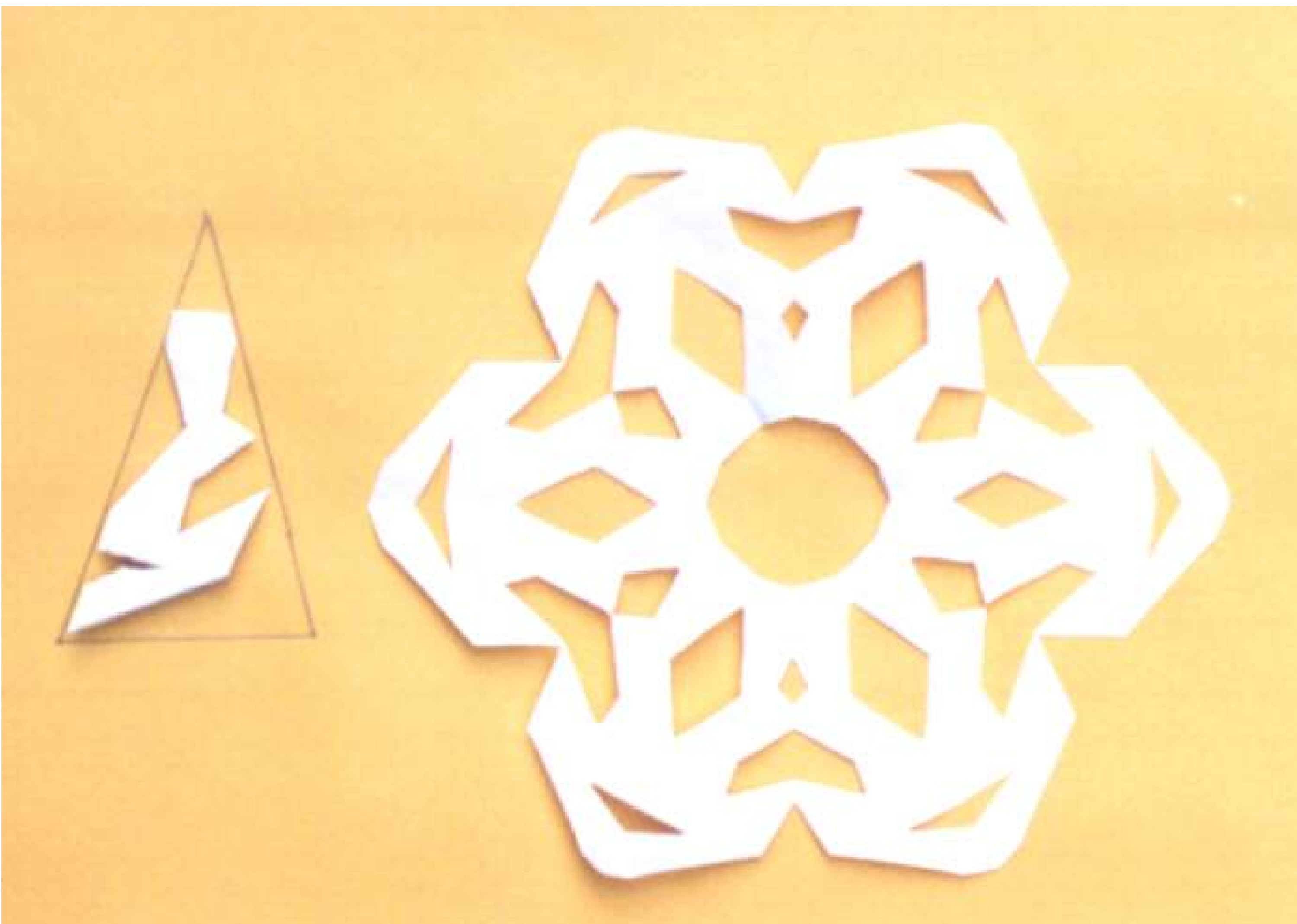
When making additional cuts for the snowflakes, the point E forms the 6 points of the star or snowflake and the point D forms the center of the star or snowflake. (If you choose to cut off D, a hole will be in the center. If you choose to cut off E, the tips will have more points!)

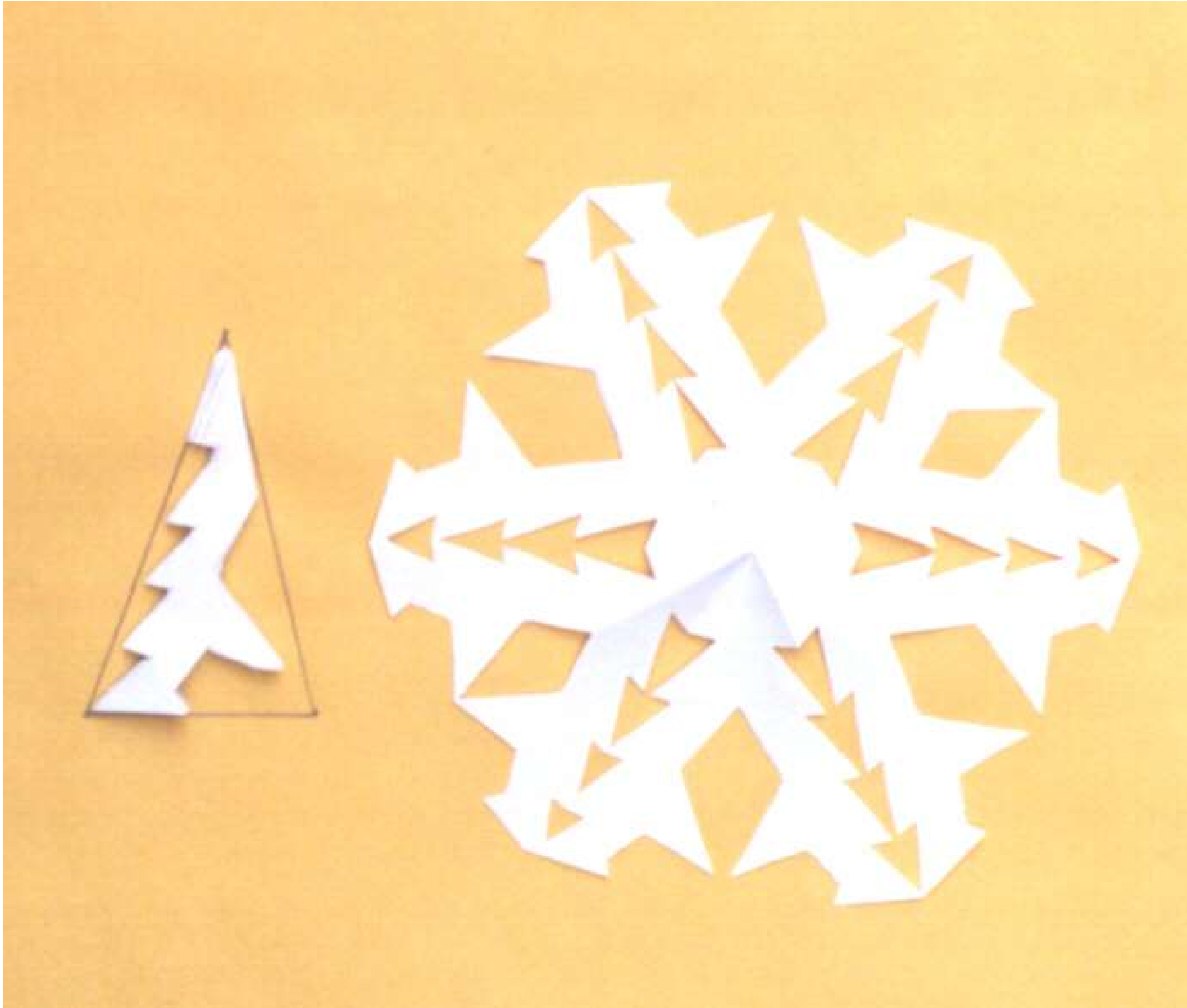
Make cuts leaving a 'path' from E to D. Then open to reveal snowflake. The snowflake can be flattened or made into a relief by folding the 12 creases from the center, alternating in and out (as shown with the 6 point star).

Shown below are different snowflakes made from different cuts.









Priced square sheets of variety paper lately? We have, and so we offer, inexpensively, 100 square sheets of various brilliant colors that are available. The sizes are square and range from 7 " x 7 " to 4 " x 4 " and 20 pound paper with some card stock. Only $5 postpaid. (Tennessee residents add 9.25% sales tax.)

Also, we offer 150+ sheets of white paper squares - at least 50 sheets each of 4x4 inches, 5x5 inches, and 6x6 inches - $5.00.

Send check to:

Maddy and Maverick, 6418 Point Pleasant Rd, Hixson, TN 37343

100% guaranteed satisfaction or we will refund your money. Just return the items within 30 days.

Need a compass with no sharp points. Draw circles from 1/4 " to 10 " diameter with new flat compass. $1.80 postpaid. 2 for $2.50 postpaid. (Tennessee residents add 9.25% sales tax.)

Click here for more information and pictures on this Safe-t Compass. School & Group discounts for large orders available. Other products available such as a compass/protractor/ruler combination.

More Free Information and Interesting Items - Home Page

Free instructions for paper Maverick boats

Free Instructions for Paper 5 Point Star

Free Instructions for Paper 6 Point Star

Free Instructions 3-D (Moravian Pensylvanian German) STARS

Please be ready to enter items you are purchasing and the total charge. Thank you.

Make payments with PayPal - it's fast, free and secure! Click here for more information

PayPal CLICK HERE TO PAY

PayPal VERIFIED

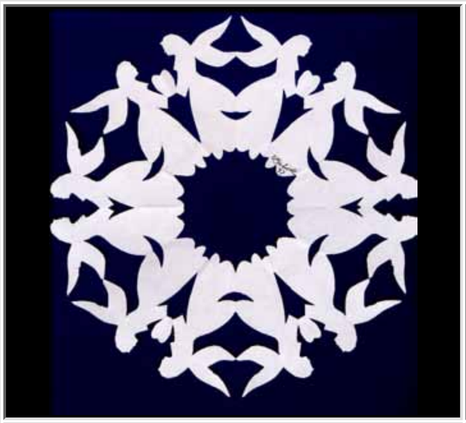
THANK YOU

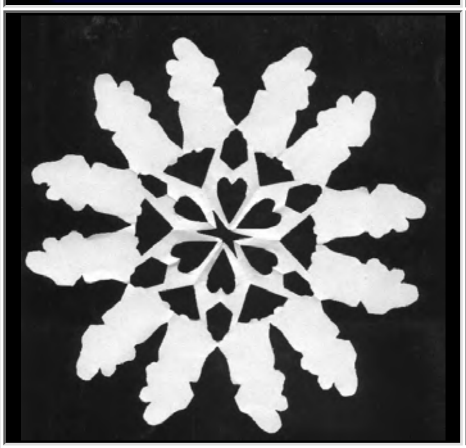
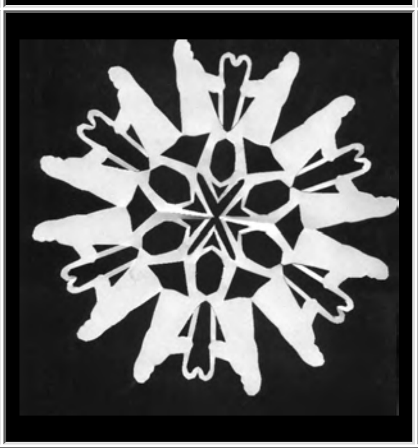
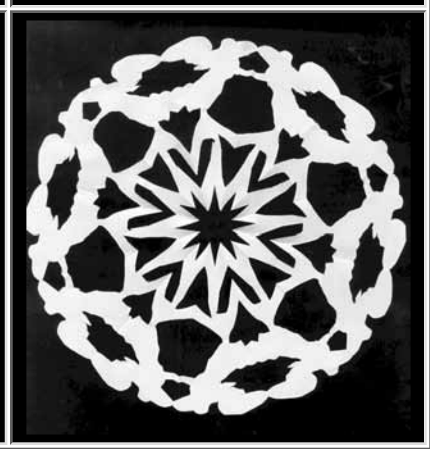
e-mail Maddy or Maverick

SNOWFLAKES

Yes, the kind you cut with scissors. Take a look at what I've done! From a distance they look like snowflakes, but can you see the image within them? Select the snowflake you would like to see actual size and in detail (except the ones on black which I haven't made an extra link for.) I have just uploaded more snowflakes for my friends on tkdnet. However, on that page, I can't show you each image in larger format (my server says I don't have enough room!) For the unusual, check out my ratite snowflakes (thanks to Myra)!

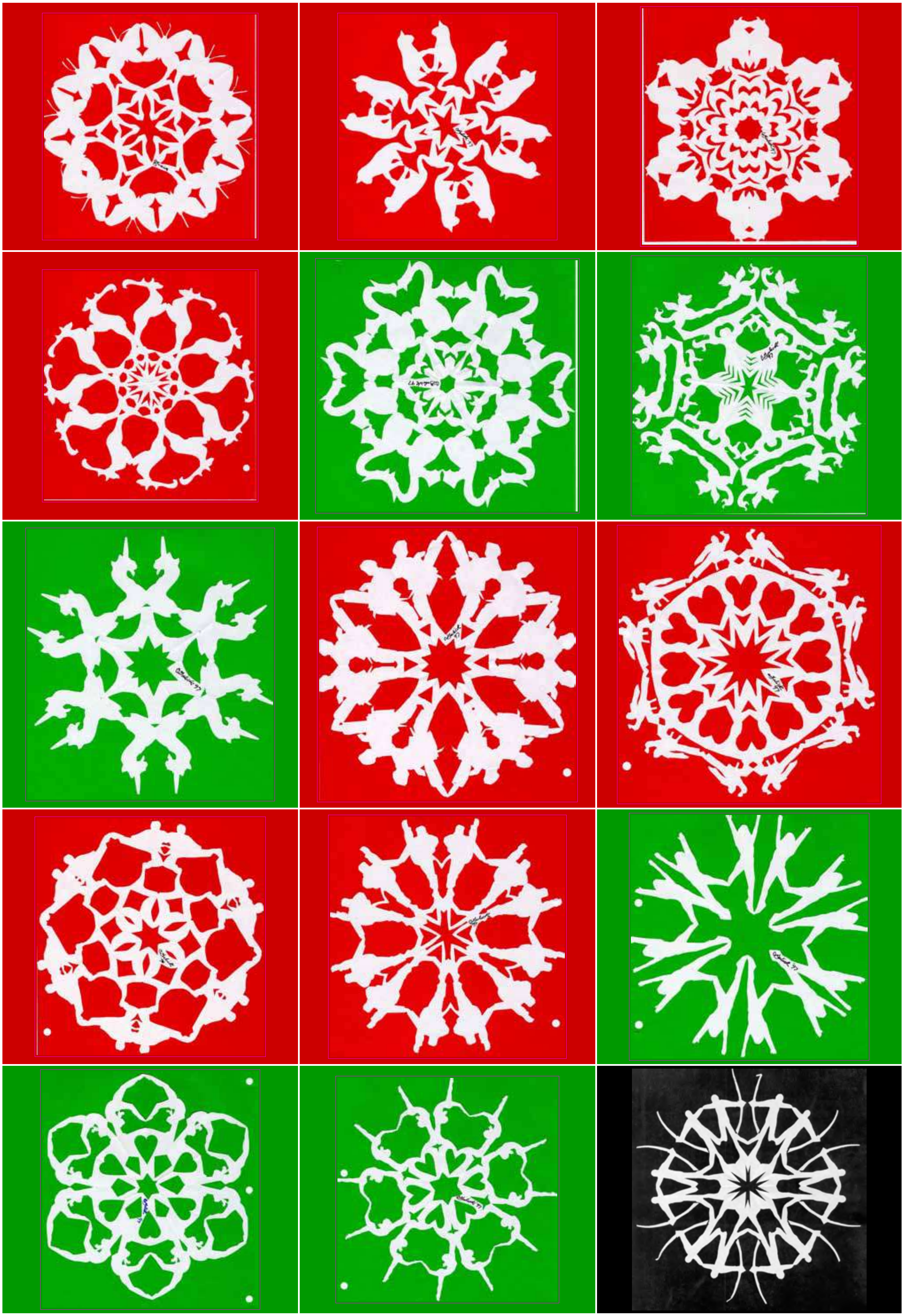
Seasonal Snowflakes: See if you can guess what each flake represents.

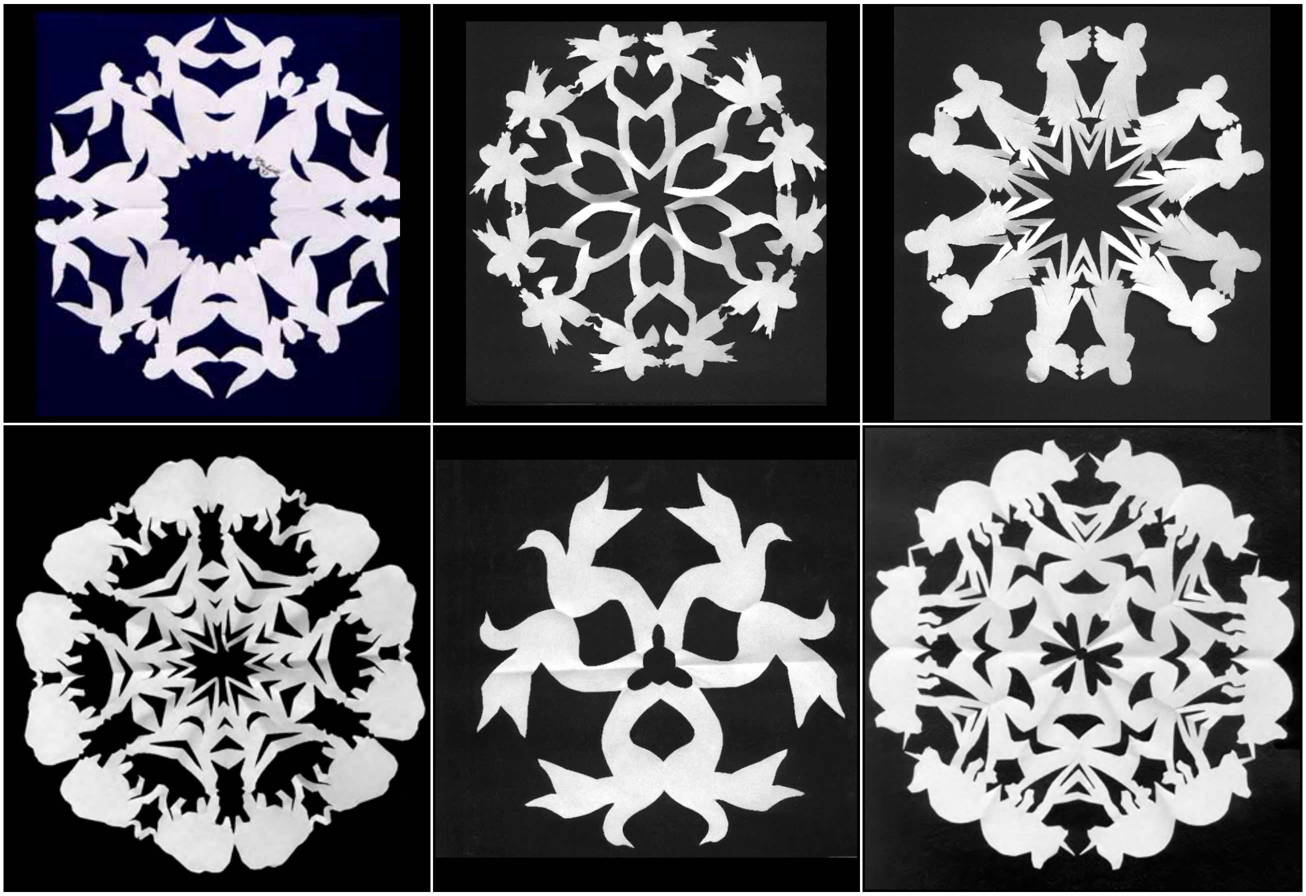


At this location, you can see how I do it, how I go from photo to snowflake.

Here are instructions on how to make your own snowflakes. I can also provide you with patterns if you're having problems with the instructions (there is a small cost). You can email me at SnowCuts@netscape.net or cgulick@tvi.cc.nm.us.



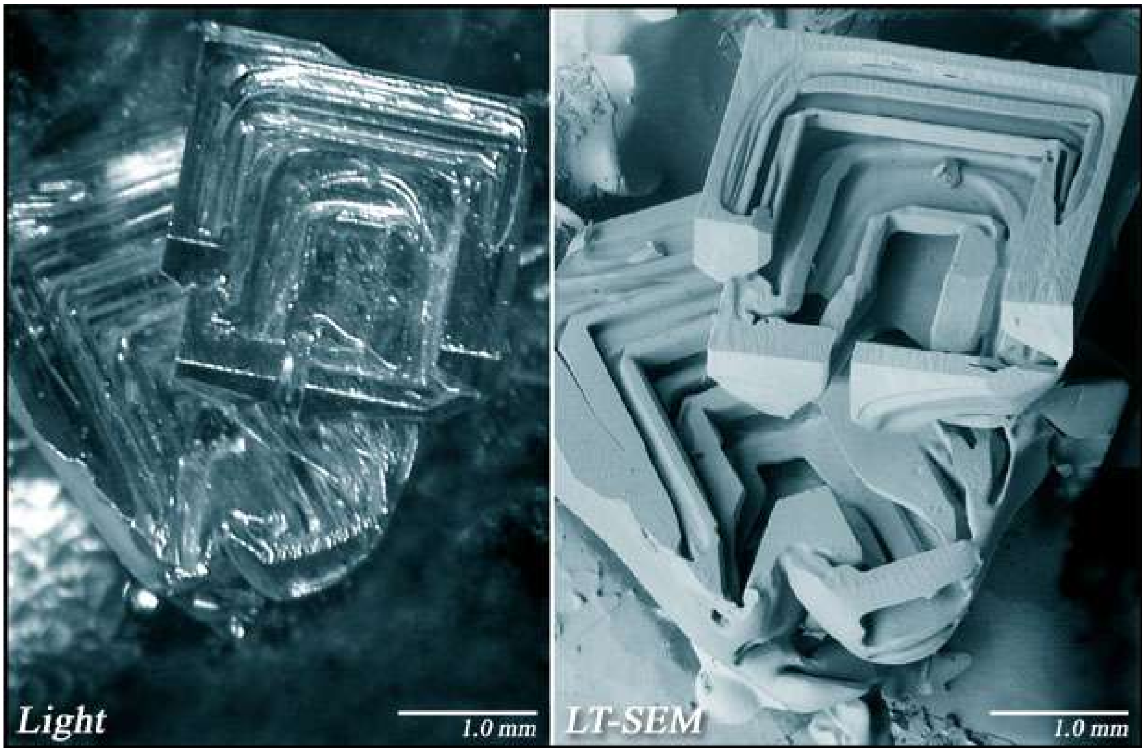


Aren't snowflakes pretty! If you choose the 'Copy to Clipboard' option you can then paste the image of your snowflake in a word processor or graphics program (then you can print from there!).

This was done by Raman Pfaff. If you would like more information, please contact me at pfaff@explorescience.com

Electron Microscopy Unit Snow Page

You will be automatically transferred to the new EMU pages in a few seconds

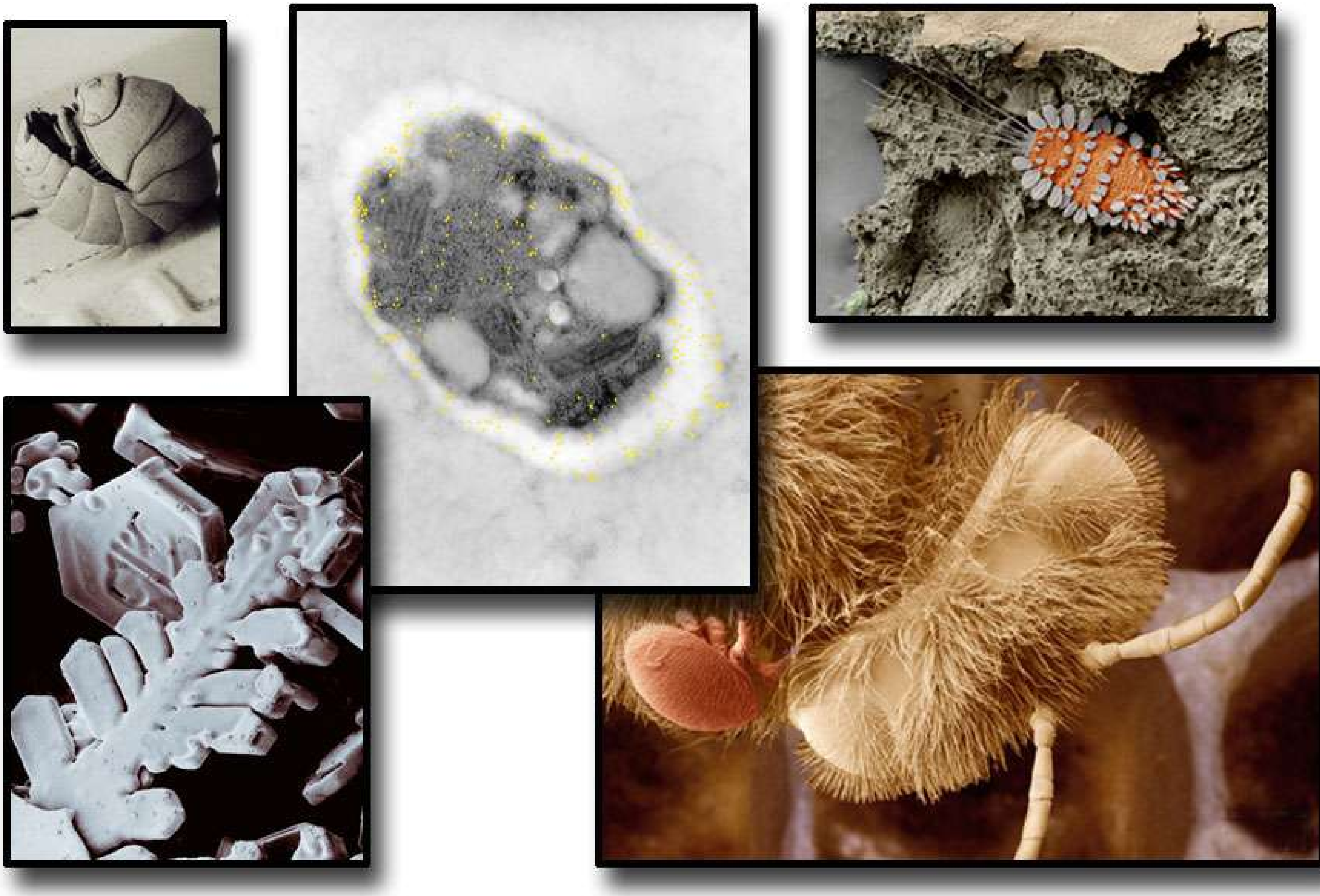


The following images were obtained using a Low Temperature Scanning Electron Microscope (LT-SEM) that is located in the Beltsville Agricultural Research Center in the Electron Microscopy Unit, Bld. 177-B, Beltsville Maryland 20705. Information gained from studying the structure of snow is vital to several areas of science as well as to activities that affect our daily lives and is only one of several agricultural research projects that are currently being pursued in this research unit.

- Pseudo Color Snow Crystals
- Selected Snow Crystals
- Light and SEM Comparative Images of Snow Crystals
- **Rime** and Graupel
- Martian Ice Crystals
- Stereo Images
- Magnification Series
- Information Contacts, Snow Links and Publication List

Eric Erbe: ErbeE@Ba.Ars.Usda.Gov LT-SEM sample collection, preparation and imaging
Christopher Pooley : PooleyC@Ba.Ars.Usda.Gov web design and image digitization
USDA, ARS, PSI, EMU.
Updated: 11/2003.

Beltsville Electron Microscopy Unit Page



The Electron Microscope Unit provides collaborative assistance for BARC scientists to use high resolution imaging for their research programs. The Electron Microscope Unit is equipped with state of the art scanning and transmission electron microscopes. The scanning electron microscope includes a cryo-stage that permits the imaging of fast frozen materials that allows an investigator to obtain images of the surface of biological and physical materials unaltered by preparative procedures. Images on web sites of snow crystals and the detail of nearly microscopic mites shows the great power of resolution inherent in this technique. The Electron Microscope Unit also possesses a high-resolution transmission microscope that is used to obtain detailed structural information from very thin sections of plastic embedded material. Subcellular structures of 0.01 um or less are easily imaged and when this approach is combined with antibody labeling it can provide not only structural but also compositional information. All of the microscopes of the Electron Microscope Unit are in the process of being outfitted with digital cameras eliminating the need for darkroom work and permitting any collaborating investigator to use images generated to prepare figures for manuscripts and grants. This will facilitate the submission of manuscripts and grant applications online that is now required by many journals and some grant agencies. There is no charge to collaborating management units to work with Electron Microscope Unit for short-term projects. For projects that might involve a long-term commitments or that might dominate the staff's, time then the Electron Microscope Unit will provide training and facilities for a member of the collaborator's staff. The Unit functions as a Beltsville Area facility and is funded by a service CRIS. Beltsville scientists who wish to use the Unit should discuss their prospective project with the appropriate member of the Unit's staff, **Eric Erbe**:, specialist in scanning electron microscopy, **Charles Murphy**:, specialist in transmission electron microscopy or **Christopher Pooley**:, specialist in digital imaging and computer techniques.
Examples of projects that Electron Microscope Unit has undertaken are shown in the following web links;

- Snow Crystal Site
- SEL Mites
- Color Stereo Mite Micrographs

- Stereo Mite Micrographs
- Examples of Micrographs

- Information, Directions to the Lab, Contacts, Snow Links and Publication List

- Back to SGIL Site

SEM Issues or Questions to: ErbeE@ba.ars.usda.gov

TEM Page Issues or Questions to: MurphyC@ba.ars.usda.gov

Web Page and Imaging Issues or Questions to: PooleyC@ba.ars.usda.gov

USDA, ARS, PSI, SGIL, EMU. Updated: 11/2003.

Trackstar has moved to a new location please update your bookmarks, you will be forwarded to the new TrackStar site. If your browser does not support automatic redirect, please click the following link:
http://trackstar.4teachers.org

WEATHER WATCH Winter Storms HOME 12-20"

Teacher's Guide Grades 3–8

Winter storms are among nature's most impressive weather spectacles. The combination of heavy snow, freezing rain, and high winds can totally disrupt modern civilization: closing down airports and roads, creating power outages, and downing telephone lines. In Winter Storm, students learn about the many ingredients and processes that go into the creation of a winter storm; experiment with creating a winter storm of their own with our Interactive Weather Maker; and discover historical winter storm patterns with our Winter Storm timeline. From January 22 to February 28, students submitted questions to our weather expert, meteorologist Jeffrey Master. These questions and answers are available online.

This project can be used in conjunction with the Weather Reporters project to augment students' proficiency with winter storms by providing hands-on lesson plans on collecting weather data in the field. Visit the Lesson Planning Suggestions section of this teacher's guide for suggestions.

Several assessment components are embedded in this lesson plan. Skill labels Skill Focus, highlight activities that address specific target skills. Targeted skills are listed in Learning Objectives. An Activity Assessment Rubric assesses student proficiency with the Ask Our Weather Expert activity. Visit the quiz page for a review and comprehension quiz on winter storm terminology.

Scholastic's Online Activities are designed to support the teaching of standards-based skills. While participating in the "Winter Storm" project, students become proficient with several of these skills. Each skill below is linked to its point of use in the Teacher's Guide.

In the course of participating in the Winter Storm project, students will:
1. Identify characteristics of weather phenomena.
2. Use Web tools to access information.
3. Analyze and interpret information to construct reasonable explanations from direct and indirect evidence.
4. Craft informed questions.
5. Use Web-based technology to communicate.

All About Winter Storms
In this introduction to winter storms, students learn about the different weather elements that contribute to major cold-weather events like blizzards and ice storms. The Winter Weather Terminology page helps students become familiar with such common but often-misunderstood terms as "wind chill" and "lake effect," make distinctions between such concepts as "winter storm warnings" and "winter advisories," and more. A Wind Chill Factor chart gives at-a-glance translations of what temperatures feel like when they are affected by this weather phenomenon.

Interactive Weather Maker
What would it be like to be a real weather person —not just someone who reports the weather, but someone who can actually control it? Using our Interactive Weather Maker (free Flash plug-in required), students turn a sunny day into a windy day, or create a rainy day, and if they create the correct conditions, students can make a blizzard — complete with a whiteout!

Winter Storm Timeline
People love to tell stories about weather, and how the storm they remember was the worst one ever! Using this interactive timeline (free Flash plug-in required), students explore famous winter storms throughout American history.

Ask Our Weather Expert
Dr. Jeffery Master, Director of Meteorology for the Weather Underground Web site, answered questions about winter storms and other weather phenomena submitted by students. These questions and answers are available online.

Project Introduction (2–3 Days)
Skill Focus Discuss winter storms that are brewing in your area or that students have learned about through the news. Ask students to relate what kinds of phenomena are typical of winter storms. Write these on the chalkboard.

Set aside time for groups of students to take turns reading "All About Winter Storms." If you have a computer lab, students should read this section individually. Then guide students to read the Winter Weather Terminology page. You may wish to distribute printouts of both of these pages.

Return to the earlier discussion on students' background knowledge of winter storms. Ask them to talk about what new knowledge they have gained, such as "Is there anything you've learned that refutes what you used to think about how winter storms develop?" Have students discuss responses in class and write them in their journals.

Scholastic Weather Reporters (ongoing)
You may wish to supplement students' knowledge of weather by weaving together activities from the "Winter Storms" project with the Scholastic Weather Reporters project. Inform students that they will learn more about local weather by taking weather samples in their area. Use the Weather Lab for a field activity in which students collect data on precipitation and other Winter Storm phenomena. Visit the Weather Reporters Teacher's Guide for an in-depth lesson plan on this subject.

Winter Storm Timeline (3–4 days)
Skill Focus Assign this activity to students at any time throughout

their work on this project. If you have a limited number of terminals, create a time schedule for individual students to visit the timeline. Encourage students to revisit the timeline as often as time allows.

Interactive Weather Maker (2–3 days)
Skill Focus Once all students have had time to experiment with the tool, set aside time for small-group or whole-class discussion for students to share their observations.

You may wish to collect data on local weather at this time. Guide students to the Scholastic Weather Reporters project. Have student groups read about making weather tools to collect weather data. Focus on tools that reflect the weather conditions in your area. Suggest that each group follow directions to make a version of one or more of the tools. Have students collect data using the tools on a daily basis, and post their results online. View the Teacher's Guide for the Weather Reporters project for other ideas on sharing and analyzing weather data.

Ask Our Weather Expert (2 days)
Introduce meteorologist Dr. Jeffrey Masters, and have students read his biography. Then Skill Focus ask students to develop two questions about winter storms, their Weather Reporters experiments, or weather in general that they would like Dr. Masters to answer.

Skill Focus Meet with students to review their questions, and make final revisions.

Have students read through the questions and answers to see if their questions were answered. If their questions have not been answered, have groups of students read them aloud and discuss possible responses.

Terminology Quiz
Distribute the Winter Storm Project Test for a formal assessment of terminology related to winter storms. The Project Test offers students exposure to standardized tests. There is a proscriptive tip before the test, written for students that advises on test-taking strategies.
1. b
2. c
3. a
4. a
5. b
6. c
7. a
8. b
9. a
10. b

NATIONAL STANDARDS CORRELATIONS

This project aids students in meeting national standards in several curriculum areas.

Math
National Council for Teachers of Mathematics:

- selects and uses appropriate instruments and technology to measure in real-world situations
- generalizes a pattern, relation or function to explain how a change in one quantity results in a change in another
- analyzes real-world data to recognize relationships using graphic models generated by technology

Reading Language Arts
International Reading Association (IRA) and the National Council of Teachers of English (NCTE)

- collects data, facts, and ideas

- uses knowledge from oral, written, and electronic sources
- compares, synthesizes, interprets, and analyzes information from different sources
- selects, organizes, and categorizes information using a wide variety of strategies
- relates new information to prior knowledge and experience
- uses text features that make information accessible and usable
- establishes authoritative stance on a subject
- develops information using facts and details · analyzes interprets, and evaluates information, ideas, organization, and language from text
- listens attentively to others and builds on others' ideas in discussions

Science
National Science Teachers Association:

- plans and implements investigative procedures
- uses equipment and technology
- collects data by observing and measuring
- analyzes and interprets information to construct reasonable explanations from direct and indirect evidence
- communicates valid conclusions
- constructs graphic structures of information using tools including computers to organize, examine, and evaluate data
- analyzes and reviews scientific explanations
- represents the natural world using models and identifies their limitations

Technology
Technology Foundation Standards for Students:

- use technology tools to enhance learning, increase productivity, and promote creativity
- use technology tools to collaborate, publish, and interact with peers, experts, and other audiences
- use a variety of media and formats to communicate information and ideas effectively to multiple audiences
- use technology to locate, evaluate, and collect information from a variety of sources
- use technology tools to process data and report results
- employ technology in the development of strategies for solving problems in the real world

History (Grades 3–8)
Challenge students to write a profile of a winter storm or other extreme local weather phenomena.

Math/Geography (Grades 3–8)
Ask students to create a map of a winter storm using information they've learned from "All About Winter Storms." Students should use a map of the United States with labels for *air mass, cold front,* and the area around which the winter storm will begin. Students can use the printable map of the United States to display their work.

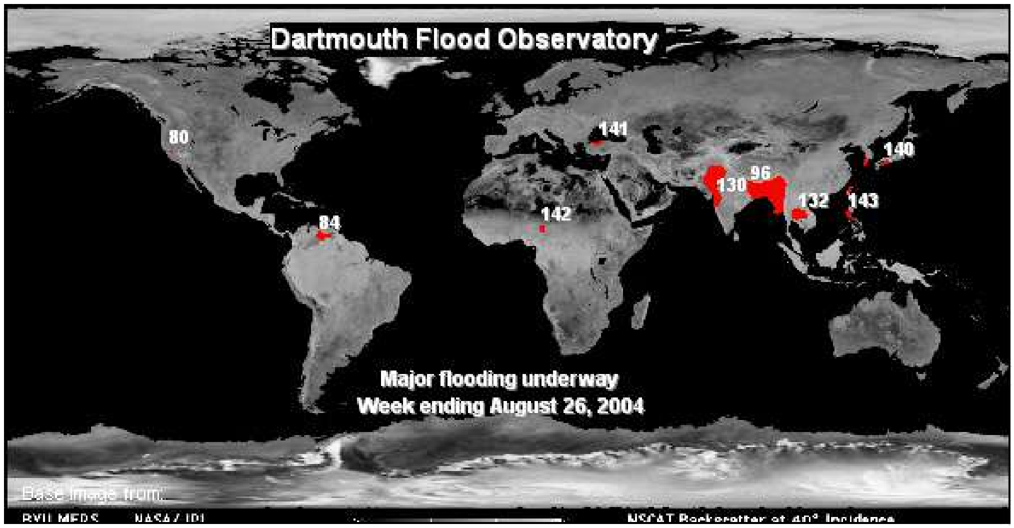
Vocabulary (Grades 3–8)
Have students write definitions for winter terms discussed in the project on index cards. Students can quiz each other about the definitions in small groups.

Writing Process (Grades 3–8)
Ask students to write a short expository paragraph discussing new information they discovered about winter storms from Dr. Masters' interview and the "Winter Storm Project." Pair up students to peer edit one another's expository paragraphs.

For information on books, Web sites, Scholastic products, and other related resources, please visit Scholastic Recommends.

- Home
- Active Archive of Large Floods, 1985-Present
  - 2004 Map
  - 2004 Table
  - Global and Regional Analyses
- World Atlas of Flood Hazard
  - Index Map (access the atlas sheets)
- Global Hydrographic Array
- Wetlands Monitoring
- Flood Detection Tools
- Explanation of Data Products
- Sample Images and Maps
- Staff
- Publications

The Observatory detects, maps, measures, and analyzes extreme flood events world-wide using satellite remote sensing. We use microwave and optical satellite imaging of selected river reaches to detect overbank flood and extreme low flow conditions. We also provide yearly catalogs, large-scale maps, and images of river floods, from 1985 to the present, and are developing methods for obtaining globally-consistent measurements of these events. As the archive of reliable data grows, it is increasingly possible to predict where and when major flooding will occur.



You can find here:

- Rapid Response Inundation Maps of large floods (example). These are useful to disaster responders. Locate the flood of interest in the Active Archive of Large Floods.
- Displays showing river flow status, world-wide. Regional versions are available, and global summaries are also presented as part of a "Sensor Web" effort that is to eventually link different satellite sysems.
- Estimates of stage and discharge along some rivers and streams on a repeating basis (go to Global Hydrographic Array homepage, version 2 reaches).
- The long-term history of flooding observed from space; compiled as a World Atlas of Flood Hazard.
- A comprehensive archive of large flood events, 1985 to the present, associated descriptive statistics, and downloadable files..

New!

Lethal Flooding at Jimani, Dominican Republic

Reuters AlertNET/ESA/Dartmouth Flood Observatory Collaboration

NOAA/Dartmouth Flood Observatory Collaboration

Analysis of Global Flood Events: 1985 to Present

NASA SENSOR WEB Flood Detection

Visit our NATO Science for Peace partners in Romania and Hungary

To order remote sensing-based flood hazard maps

Direct Questions to:
Bob Brakenridge
Elaine Anderson

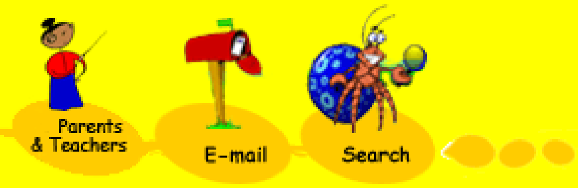
This work is partially supported by NASA Earth Science Enterprise grant NAG5-13192 to Dartmouth College, Hanover NH 03755 USA (G. R. Brakenridge, Principal Investigator). Data access is provided by ESA (ERS investigation A02.USA161), the NASA Radarsat/ADRO program, the NASA DAACs, and the NOAA Satellite Active Archive. We share some resources also with the U.S. Army Corps of Engineers through their Remote Sensing and Geographic Information Systems Center.

The following example shows how to cite the use of information from this site in a publication. List the principal investigators, year of data you used, map or data title or description, city and and country, institution, "digital media", and web page accessed.

Brakenridge, G.R., Anderson, E., Caquard, S., 2003, Flood Inundation Map DFO 2003-282, Dartmouth Flood Observatory, Hanover, USA, digital media, http://www.dartmouth.edu/~floods/2003282.html.

FEMA for Kids

FEDERAL EMERGENCY MANAGEMENT AGENCY

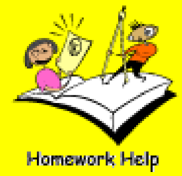


What's New...

the FEMA 'Zine

Welcome to FEMA for Kids! I'm Herman, the spokescrab for the site. This site teaches you how to be prepared for disasters and prevent disaster damage. You can also learn what causes disasters, play games, read stories and become a Disaster Action Kid. And don't forget to learn about FEMA. A story about my search for a disaster-proof shell is great reading, too!

Hey, parents and teachers -- we have resources for you! Parents & Teachers page has activities, curriculum and safety information you can use in the classroom or at home!



Our Privacy Policy is here and our Online Safety information is here.

FEMA for Kids

Federal Emergency Management Agency

FLASH FLOOD!

Floods are the most common and widespread of all weather-related natural disasters. Most communities in the United States have experienced flooding after spring rains, heavy thunderstorms, or winter snow thaws. Floods have enough power to change the course of rivers and bury houses in mud. And flash floods are the most dangerous kind of floods, because they combine the destructive power of a flood with incredible speed and unpredictability. Learn more about the force of flash floods when you read through this lesson.

About Floods explains the difference between an ordinary flood and a flash flood. You can also visit other web sites that have pictures of flood damage.

Flood Types explains the different types of floods besides flash floods, and has a quiz that lets you pick the right flood.

Flood Prep can get you prepared for a flood, with links to explain and help you prepare disaster plans and survival kits.

Safety Rules is where you'll find out what you should and should NOT do during a flash flood.

The **Flood Quiz** is a review of the information in this lesson as an online quiz, with your results given to you instantly.

Flood Watch will let you search the Web for flash flood warnings. You can record what you find on your own weather map.

The **Teacher's Guide** is for teachers who want to read about the lesson plan and objectives for the Flash Flood! lesson.

Click on the Flash Flood! logo on any page to return here.

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Flood Your Desktop | River's Gift
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Retired Site

The "Newton's Apple" site has been retired from pbs.org.

For information about this series, including online activity guides, and how to order the home videos and additional educational materials for classroom use, please visit http://www.tpt.org/newtons/.

To find related content on pbs.org, try a keyword search, visit a related topic area using the pulldown menu at the top of this page, or browse our Programs A-Z menu.

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Building, renovating & maintaining > Coping with Emergencies > Floods > What to do before and after

FLOODS

What to do before and after

Beyond the human toll taken in lives and suffering, flood damage costs Canadian taxpayers millions of dollars annually.

Though governments at every level work to reduce the risk of floods, the first line of defence always rests with the individual. Each of us has a responsibility to protect our homes and families to the greatest extent possible. By planning ahead and taking sensible precautions, you can do your part to minimize flood damage.

Flood threats to particular areas can usually be forecast in a number of ways:

- by constant evaluation of rising water tables that result from heavy rain
- through surveys of snow conditions in river drainage basins
- by meteorological observations and forecasts.

Flash or sudden flooding, in which warning time is extremely limited, can result from other causes such as earthquakes, tsunamis or tidal waves, hurricanes. violent storms or bursting of dams.

In all cases, local government authorities try to keep residents informed of developments in areas most likely to be affected by flooding. Regular media advisories will recommend actions people should take to limit or prevent disaster. As the need arises, more detailed instructions by municipal or provincial authorities will be given.

Before the Flood

After the Flood

First Steps in Clean-up

Water-Damaged Heirlooms and Antiques

What to Keep or Discard

Before Moving Back in

Other Self Help Advice

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Press here if your browser does not automatically go to Mark Isaak's flood stories page.

NASA'S OBSERVATORIUM
TEACHER'S GUIDES

Flood: Just Doing My Job

Activities|Age/Grade|Facts|Fun|Links|Objectives|Questions|Quiz|Related Topics|Summary|Vocabulary

Want to read about Flood: Just Doing My Job?
*Article will open in a new window.

Summary of Article

This article describes how satellite images were used to help evacuation procedures in the Midwestern flood of 1993. Torrential rains caused the waters of the Mississippi, Missouri, and Illinois Rivers and their tributaries to overflow their banks, causing massive flooding in the towns and cities on these rivers. The article focuses on the work of one man, Lee Blackmore. Lee was an image analyst and GIS specialist with the St. Louis Community Development Agency (CDA). He used satellite images to help officials in evacuation procedures in the business district affected by the flooding River Des Peres. This article focuses on his efforts.

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Suggested Age/Grade Levels

Age Level: 11 - 16
Grade Level: 6th grade - 10th grade

Related Topics:

Geography

Discuss with students the communities along the Illinois, Mississippi, and Missouri Rivers.

History

St. Louis, at one time, was a very large city. It was the gateway to the West and played a large part in the Lewis and Clark expedition. Discuss this expedition and the significance of this large city on the banks of the Mississippi with your class.

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Objectives

After studying the article, students should be able to:

- Discuss how satellite imagery was used to evacuate parts of South St. Louis.

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Classroom Activities

Please check out our Eyes in the Sky article. This is designed as a classroom activity and includes the same photos of the 1993 St. Louis flooding as Flood: Just Doing My Job. Students will be able to analyze and interpret photos of the flood and of fires at Yellowstone National Park.

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Questions for Discussion

Q: How did Lee use the satellite images to help in the evacuation procedures?
A: Lee used the satellite images to produce a map that would show which buildings were in immediate danger of flooding. First, he took data depicting streets and properties, or plats. Next, he added the locations of buildings. Finally, the current boundaries of the floodwaters were extracted from the Thematic Mapper (TM) data and added to the map.

Q: Can you think of other circumstances where satellite images could be used to help save lives and property?
A: A forest fire is one circumstance in which satellite images could be used to help save lives and property.

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Quiz

Click here for a Flood quiz.
*Please use your browser's back button to return to the Flood teacher's guide.

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Just the Facts

Using satellite imagery, an electronically superimposed digital map was created showing parcels, building locations, and the normal boundaries of the River Des Peres. The resulting map clearly showed the St. Louis police where to concentrate their evacuation efforts.

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Links to Relevant Web Sites and Additional Resources

http://observe.ivv.nasa.gov/nasa/exhibits/flood/flood_5.html

*Page will open in a new window.

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Vocabulary

Thematic Mapper (TM): instruments carried on Landsat and other satellites which measure the amount of energy reflected and emitted in several discrete portions, or bands, of the electromagnetic (EM) spectrum. Various visible and infrared bands were chosen to measure reflected and emitted energy in areas of the spectrum that correspond to known responses of the target materials (for example, specific characteristics of land, vegetation, water, rocks, and temperature).

For more complete information on the TM, please check out the Observatorium's article on
Landsat's Thematic Mapping Bands.
*Article will open in a new window.

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For Fun

Just for fun, play our Flood Wordsearch game.
*Please use your browser's back button to return to the Flood teacher's guide.

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Highway Conditions

Flood Information

Manitoba Highways Conditions (Français)

Media Update (Français)

Manitoba Emergency Measures Organization

- Family Emergency Handbook flood information (Français)
- Emergency Measures for Flooding
- Sandbag Dike Construction
- Guidelines for Flash Board Construction
- After Flooding: Exercising Caution
- Controlling Mold and Moisture
- Understanding Mold
- Mold Concerns in homes
- Disaster Financial Assistance

Manitoba Conservation Water Branch

- Flood Condition and Forecast Reports
- Frequently Requested Information
- Water Levels and Flows

Manitoba Health Emergency Services Branch

- Well Water Fact Sheets (March 2001)
- Public Health boil water notice (Français)

Get Adobe Acrobat Reader

- Agriculture Information
- Environment Canada Manitoba forecast (Français)

Hi, welcome to my site! My name is Tina and I still live with my parents in Miami, USA
I made this site to let you guys know that you can meet me on the internet.
I'm single and I'd love to show you my tight body on my webcam for free but
I don't want any kids to see me naked so please verify your age before.

My webcam is almost always on, even if I'm not there, you may find my sister online or look at me while I'm sleeping :) You will also have access to a huge archive of my past shows!

My webcam has sound too! You will be able to listen to me while you type in the chat box to interact. You will find lots of cute girls when you become a member but I'm very jealous and I will do whatever is your fantasy to please you. I can play with a dildo, invite my friend or sister to play...anything ;)

Now, you only need to **click here and fill out the form** to verify that you are an adult and you will see my webcam! It takes only 2 minutes and it's free! I can't wait to see you there.

Disclaimer: Me, my sister and all members/users on this site are 18+ years of age.

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Global Warming | Ozone Depletion | Sustainability | Weather

See also the Encyclopedia of Sustainable Development

Best viewed with Internet Explorer at 1024 x 768 resolution.

Bringing The Greenhouse Effect Down To Earth

Grade Level: 9-12

Purpose: To compare the amount of Carbon Dioxide (CO2) in four different sources of gases.

Materials:

(Enough for each team of two or four students)
5 vials or test tubes
A graduated cylinder
A funnel straw
A marble-size piece of modeling clay
4 different colored balloons
4 twist-ties
A narrow-necked bottle (the neck should be narrow enough for a balloon to fit over it)
A dropping bottle of bromthymol blue indicator solution
A dropping bottle of dilute household ammonia (1 part ammonia to 50 parts distilled water)
100 mL vinegar
5 mL baking soda
Safety goggles for wear at all times

Teacher's Lab Notes:

The students will be filling balloons with pure carbon dioxide, exhaled air, and ambient air. For safety reasons, you should fill the balloons with automobile exhaust. You should wear thick gloves to protect your hands from being burned. Fill the balloons in an open area and when a slight breeze is blowing to keep the exhaust gases away from your face. Place a balloon over the narrow end of a metal funnel and place the wide end of the funnel over the exhaust pipe of a running car. When inflated, the balloons should be about 7.5 cm in diameter. It may be easier to overinflate the balloon and then let a little gas escape. Twist and tie the balloon. Repeat the procedure with the same color balloon until you have one for each lab group.

The ambient air solution in vial A will not turn yellow. The level of CO2 in ambient air is too low to affect bromthymol blue.

Students will need around 60 drops of the diluted ammonia to neutralize the solution in vial D (vinegar-baking soda reaction). The other two vials should require between 7 and 40 drops. Caution students to add the drops slowly and shake solutions between drops so they can get a careful record of when the color changes back to the same color blue as the control.

Since the students will have to add a relatively large amount of ammonia to the solution in vial D, the color of this sample may be affected by dilution. To equalize this effect, you can have students add some water to the other samples to make the volume in each sample equal. This is easiest to do if sample D is titrated last.

Lab Procedure:

1. Add 15 mL of water and 10 drops of bromthymol blue indicator solution to each vial or test tube. Label the vials A, B, C, D, and Control.

2. Fill each balloon until it has a 7.5 diameter.
Sample A (Ambient Air) - Use a tire pump to inflate the balloon to the required diameter. Twist the rubber neck of the balloon and fasten it shut with a twist tie. The tie should be at least 1 cm from the opening of the balloon. Record the color of the balloon used for this sample.
Sample B (Human Exhalation) - Have one team member blow up a balloon to the required diameter. Twist and tie the balloon, and record balloon color.
Sample C (Automobile Exhaust) - Your teacher will supply you with this balloon. Record the color.
Sample D (Nearly pure CO2) - Put 100 mL of vinegar in the narrow-necked bottle. Using a funnel, add 5 mL of baking soda. Let the

mixture bubble for 3 seconds to drive the air out, then slip the balloon over the neck of the bottle. Inflate the balloon to the proper diameter. Twist, tie, and record the color.

3. Soften the clay and wrap it around one end of the straw to make a small airtight collar that will fit into the neck of a balloon. The collar should look like a cone with the straw in its middle, and should be large enough to plug the neck of the balloon.

4. Pick up Balloon A. Keeping the tie on it, slip the balloon's neck over the clay collar and hold it against the collar to make an airtight seal. Place the other end of the straw into the vial of water and bromthymol blue labelled A. Have another partner remove the tie on the balloon and slowly untwist the balloon. Keeping the neck of the balloon pinched to control the flow of gas, gently squeeze the balloon so the gas slowly bubbles through the solution.

5. Repeat the same procedure with the other balloons and their respective vials. In some cases, the bromthymol blue solution will change color, from blue to yellow, indicating the presence of carbonic acid formed from CO2.

6. Analyze each of the samples by titrating them with drops of dilute ammonia. Ammonia neutralizes the carbonic acid. The bromthymol blue will return to a blue color when all the acid has reacted. Add drops of ammonia to each of the samples that turned yellow, carefully counting the number of drops needed until they are about the same color as your control. Record the results.

Post Lab Discussion:

Make a chart on the board to pool each group's results. Ask the students which samples had the most and the least carbon dioxide. Why didn't the ambient air sample not turn yellow? (The test isn't sensitive enough to detect low concentrations of CO2.) Carbon dioxide is a natural part of our atmosphere, but too much CO2 could make the Earth warmer through an increased greenhouse effect. Why is automobile exhaust a concern? What ways could you reduce the amount of CO2 you create? How could a city reduce the amount of CO2 they emit? What's more important, to develop and adapt cars with a new fuel that's safe for the environment or to improve public transportation systems? What alternative power sources could be used with cars? (Solar, electric, methanol.) Why might it be difficult for the public to start using an alternative source? (Car industry not mass-producing new cars, expense of buying new car, less power/speed than gas- powered car.)

This activity is used with the permission of Climate Protection Institute. CTI publishes "Greenhouse Gazette" and other programs. To receive more information about CTI and other activities, write and tell them what grade you teach at 5833 Balmoral Dr., Oakland, CA 94619. This activity appeared in The Science Teacher, May 1989.

The Greenhouse Effect In A Jar

Grade Level: K - 8

This simple experiment serves as an introduction to the greenhouse effect. Students can see for themselves the effects of a greenhouse, and relate this understanding to what occurs in our atmosphere.

Objectives:

1. Help students understand the greenhouse effect as a physical phenomenon.

2. Use simple experimentation techniques including: observing and recording data, use of a control, drawing conclusions from results, use of a model.

Materials:

For every group of (about) four students:

2 Small thermometers
1 Jar or other see-through container
1 Clock or watch
1 Copy of the worksheet
Sunlamp or access to a sunny area to perform the experiment

Method:

Group the students and distribute the materials. Each group should place their thermometers a few inches apart under the sunlamp or in direct sunlight.

Wait about three minutes so the thermometers will be giving accurate readings, and then have the students record the temperature readings on both thermometers as well as the time.

Each group should now place their jar over one of their thermometers, taking care that the jar does not cast a shadow over the uncovered one. If the thermometers are too large to remain horizontal inside the jars, it is fine to stand them against an inner side. Every minute, for ten minutes, the students should record the readings of both thermometers.

Explanation

The air over the exposed thermometer is constantly changing, and as it gets warm it is replaced by cooler air. Because the air in the jar cannot circulate to the rest of the room, this air stays in the sunlight and gets warmer and warmer. A similar trapping of heat happens in the Earth's atmosphere. Sunlight passes through the atmosphere and warms the Earth's surface. The heat radiating from the surface is trapped by greenhouse gasses. Without an atmosphere, the Earth's temperature would average about 0F. This warming due to heat-trapping gasses is called the "Greenhouse Effect." Both the atmosphere and the jar allow light to enter, but then trap that energy when it is converted to heat. They work differently, however, because the jar keeps in the heated air, while the greenhouse gasses absorb radiative heat.

Going Further:

Students can graph their data. To simulate global warming, the experiment can be done using two jars, one filled with air and the other with carbon dioxide.

The Greenhouse Effect

Instructions

1) Place the two thermometers in the sunlight for a few minutes to let them get warm.

2) Record the readings of both thermometers at the top of the columns.

3) Record the time next to the starting temperatures and place the jar over thermometer #1.

4) Every minute, record the readings of both thermometers without disturbing them.

Data

Observation Number	Thermometer #1	Thermometer #2
Time		
Start		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Global Change Research

Earth Surface Dynamics

The earth's surface does not exist in a static, unchanging "natural" condition interrupted only by the work of humans, but instead it is a dynamic system of which humans are a part. Knowledge about changes to the Earth's surface and the underlying processes that induce them has enormous impact on how society responds to these changes and, ultimately, the cost of responding to change. USGS Global Change Research activities strive to achieve a whole-system understanding of the interrelationships among earth surface processes, ecological systems, and human activities. Activities of the program focus on documenting, analyzing, and modeling the character of past and present environments and the geological, biological, hydrological, and geochemical processes involved in environmental change so that future environmental changes and impacts can be anticipated.

What's New?

- Site-Specific Soil-Carbon Database for Mineral Soils of the Upper Mississippi River Basin
- Atlantic Estuaries: Chesapeake Bay
- Ecosystem and Climate History of Alaska

Research Activities

- Overview of selected USGS Global Change research activities
- Atlantic Estuaries: Chesapeake Bay
- Alaskan Quaternary Climate Change
- Biology and Global Change - Overview
- Biology and Global Change - Research Activities
- Carbon Cycle Research
- Coastal-Change and Glaciological Maps of Antarctica
- Coastal-Change and Glaciological Maps of the Antarctic Peninsula
- Climate, Land Use, and Environmental Sensitivity
- A Devil's Hole Primer
- Ecosystem and Climate History of Alaska
- Glacier Studies
- Hydroclimatology

- Impacts of Climate Change and Land Use on the Southwestern U.S.
- Land Characterization and Satellite Data Management
- Lake/Catchment Systems (LACS)
- Last Interglacial Timing & Environment
- Rio Puerco Basin Studies
- Volcano Emissions
- Water, Energy, and Biochemical Budgets

Available Data Sets

Fact Sheets

Frequently Asked Questions

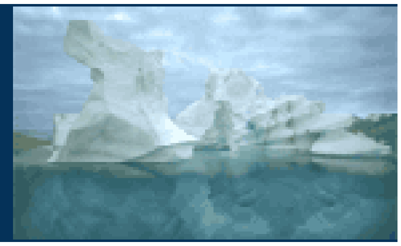
U.S. Global Change Research Program

U.S. Climate Change Science Program

U.S. Department of the Interior, U.S. Geological Survey
This page is http://geochange.er.usgs.gov/
Maintained by Randy Schumann
Last modified Monday, 23-Aug-2004 11:51:26 EDT

Environment Canada   Environnement Canada

Climate Change
Changement climatique



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Canada

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What is Climate Change?
How Will Climate Change Affect Us?
What is Canada Doing?
The One-Tonne Challenge
Climate Change Action Fund
Technology Early Action Measures
Offsets System
Opportunities Envelope

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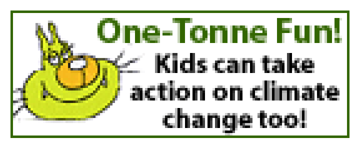
Together, we can do it.

Welcome to the Government of Canada Climate Change web site. Learn about the science, impacts and adaptation to climate change and how individuals, governments, businesses, industry and communities take action by reducing greenhouse gas emissions.

Find out what you can do to reduce your GHG emissions and learn how to use less energy, save money, improve air quality and protect our environment by taking the One-Tonne Challenge.



What's New ...

- Scientists launch giant research balloon to study ozone layer [August 18, 2004]
- Canadian athletes are competing to be the best in the world at the Athens 2004 summer Olympics. Back home, they're "Champions for One-Tonne Challenge". [August 16, 2004]
- Watch the new Energy Efficiency videos [August 11, 2004]
- Biodiesel-fuelled cruisers to ply St. Lawrence River and Lachine Canal from June to October 2004 under BioMer project [July 28, 2004]

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Last Updated: 2004-08-23

Important Notices

For all Climate Change Internet related inquiries, please contact the Administrator.

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Electronic Visualization

Unit

Global Warming Unit

On this page:

- **Grade level:** Middle School, High School
- **Subject Area:** Science and Language Arts

Unit Description

Many people are concerned about the possibility that the earth is getting warmer and the effects this change might have on the earth's ecosystem. This unit includes classroom activities to help students understand global warming and its possible effects on human beings. Lessons in the unit provide students with opportunities to study global climate changes, discuss and debate the current arguments for and against global warming and the Greenhouse Effect, investigate the possibility of global warming and the Greenhouse Effect, and present their findings in the form of research reports.

Objectives

Students will:

- Learn about changes in global weather patterns and climate over long periods of time.
- Study and debate the possibility of a Greenhouse Effect and its impact on the earth.
- Use the Greenhouse Effect Visualizer to understand possible greenhouse effect changes.
- Present their findings to the school (and others) by creating global warming reports and presenting them at an earth day event.
- Learn to use the Internet as a resource for research.

Materials and Resources

In developing our lessons and activities, we made some assumptions about the hardware and software that would be available in the classroom for teachers who visit the LETSNet Website. We assume that teachers using our Internet-based lessons or activities have a computer (PC or Macintosh) with the necessary hardware components (mouse, keyboard, and monitor) as well as software (operating system, TCP/IP software, networking or dial-up software, e-mail and a World Wide Web client program, preferably Netscape, but perhaps Mosaic or Lynx). In the section below, we specify any "special" hardware or software requirements for a lesson or activity (in addition to those described above) and the level of Internet access required to do the activity.

1. **Special hardware requirements:** None.
2. **Special software requirements:** None.
3. **Internet access:** Medium-speed (28,000 BPS via modem), or High-speed (greater than 1 MBPS via network). It should be noted that medium and high speed connections are preferable for viewing Web pages on the Internet.

Unit Lesson Plans

1. Lesson One: Introduction to Global Warming. This lesson uses traditional and on-line resources to introduce students to basic information on global climate and atmospheric changes over time.
2. Lesson Two: The Greenhouse Effect Debate. Students discuss and debate the possibility of a Greenhouse Effect and its possible impact on the earth.
3. Lesson Three: The Greenhouse Effect Visualizer. Students work in groups using the Greenhouse Effect Visualizer, and other available on-line visualization tools, to study global climate changes looking for evidence for and against global warming and the Greenhouse Effect.
4. Lesson Four: Writing and Editing a Research Report on Global Warming.

Following their research, students write and peer edit reports on global warming and the Greenhouse Effect. Students are encouraged to read and make suggestions for improving reports of students who adopt different positions on global warming.

5. Lesson Five: Presentation to the School. Following the first four lessons, a special school earth day is planned where students present their research reports, along with any other associated products (models, diagrams, Web-pages, etc.) to the rest of the class and school.

Relation to Standards

The Global Warming unit contains activities that encourage and support student learning about science, especially weather and global patterns. In developing these lessons, we have considered the science standards of the National Academy of Sciences and the American Association for the Advancement of Science. The Global Warming Unit also supports classroom activities in the area of language arts that conform to standards in writing and editing.

One Computer versus Many

The plans for this unit are tailored to fit teaching situations where students have access to several computers with an Internet connection. To accommodate classrooms that do not have access to a computer lab with full Internet connections, students can work in research groups to explore Internet sites and conduct their research.

If you have only one computer with Internet access, you may choose to do one of the following:

- If you have the technology, you may hook-up the computer to a TV monitor or LCD projector. This will allow the whole class to see sites in the preliminary stages when students are exploring sites created by other children.
- You may choose to have students rotate through computer with Internet access in groups.
- You may also download files from the Internet and save them to a disk. Then transfer Netscape [http://home.netscape.com] onto your other computers. Now you can transfer the files you down-loaded and saved to a disk to the other non-internet computers to view with Netscape. This will not allow students to explore the pages with hyper-links, but they will be able to access and view the information by opening each file with Netscape.

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Past program of the NRTEE

National Forum on Climate Change

The National Round Table brought together a citizens panel of 25 respected, objective Canadians in a National Forum on Climate Change. Endorsed by the Prime Minister, the Forum was intended to assist Canadians to better understand the climate change issue and all its implications.

The Forum s panellists were selected from a stratified random sample of Order of Canada recipients   accomplished Canadians who have been recognized for their outstanding service to Canada in such areas as community voluntarism, philanthropy, visual arts, sports, education, health care and business. The Forum was unique, precisely because it was unbiased and began with no predetermined views on the potential impact of climate change, or on the most appropriate response for Canada. This panel of citizens was provided with the full range of expert opinion and knowledge and examined all sides of the climate change debate.

The National Forum on Climate Change presented a Declaration to the Prime Minister, all levels of government, and Canadians as a whole in June 1998. In terms of key messages, the Forum members were clear: on the balance of evidence, and in the face of scientific and economic uncertainty, the time for action is now.

National Forum on Climate Change Declaration

View National Forum on Climate Change Video

Forum Members

Proceedings:
Session 1 - February 16-17, 1998
Session 2 - March 9-10, 1998
Session 3 - April 5-7, 1998

Glossary - Selected Climate Change Terms and Acronyms

Climate Change

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Climate Change

Climate change has arrived. Through erratic weather patterns, forest fires and glacier melt we are already experiencing the effects of climate change. Worse, the process of climate change, based on the levels of greenhouse gases we have already put in the atmosphere, is likely to increase the severity and frequency of severe weather events. If we allow levels of greenhouse gases to continue to rise, the disasters of today will be dwarfed by future catastrophic impacts.

Clearly, one of humanity's principal challenges in this century will be to stop climate change. To do this, we must drastically reduce our greenhouse gas emissions (GHG) – gases such as carbon monoxide, methane and nitrous oxide that trap heat in the atmosphere, raising global temperature and thereby spurring climate change.

Humans have become addicted to burning fossil fuels for energy, a principal cause of human-generated greenhouse gas emissions. The ongoing assault on the world's forests through burning and cutting is also a significant source of carbon dioxide emissions. Worse still, the clearing of the forests eliminates their ability to absorb carbon from the atmosphere, compounding the concentration of greenhouse gases in the atmosphere still more.

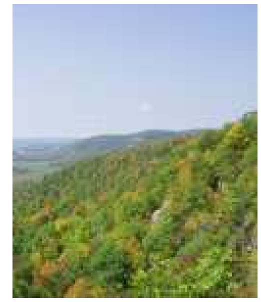
As early as the 1970s, scientists began to warn that humanity's ever-increasing production of greenhouse gas emissions would change the Earth's climate. In 1992, the world's leaders began to heed their warnings at the Rio Summit when Canada and 186 other countries signed the United Nations - Framework Convention on Climate Change. Signatory countries agreed to a long-term objective to "stabilize GHG concentrations in the atmosphere."

By ratifying the Kyoto Protocol on December 17, 2002, Canada committed to lowering its greenhouse gas emissions to 6% below 1990 levels by 2012.

But Kyoto is only the first step. Stabilizing atmospheric concentrations of greenhouse gas emissions will require a reduction in global emissions of at least 50% below 1990 levels.

The Sierra Club of Canada believes that our common future depends on making the transition to a low-carbon. energy efficient society. We work to ensure that Canada meets and surpasses and Kyoto goals. All countries, including Canada, must shift support from big, centralised and polluting energy sources, such as fossil fuels and nuclear power, to renewable energies and energy efficiency programs.

Over the long-term, Sierra Club of Canada's goal is to build broad public support for the transition to a low-carbon energy efficient society.



Campaigns

CAFE Canada
Kyoto and Beyond
New England / Eastern Canada Regional Targets

Take Action
Media
Links
Publications

Information and Resources

Kyoto Report Card

One year after ratifying the Kyoto Protocol the question is still asked: “Can Canada meet its Kyoto commitments?” The answer is resoundingly, “YES”. To make our targets in 2010, the federal government in 2004 should declare a long-term goal to reduce Canada’s total greenhouse gas emissions by 50% by 2030.

version française

Film Review: The Day After Tomorrow

"The Day After Tomorrow, which opened in theaters across North America on May 28th is a surprisingly engaging disaster movie ... " more

The Day After Tomorrow Factsheet

Separating the Science from the Science Fiction

Lighting the Way: The Sierra Club's Look at First Steps Toward a Clean Energy Future

The energy-delivery system in North America is in trouble, and the harmful effects of this are being felt today in the form of health problems, environmental damage, and a system that doesn’t meet today’s needs. The Sierra Club U.S. and Sierra Club Canada have surveyed energy programs and found that each of the states and provinces in the northeast United States and Atlantic Canada has taken some useful steps that serve as examples of opportunities for all.

Sierra Club of Canada launches CAFE Canada Campaign!

As part of our ongoing work to ensure that the federal government makes good on its promise to implement the Kyoto Protocol, the Sierra Club of Canada is launching the CAFE Canada Campaign to persuade the federal government to follow through on its commitment to improve the fuel efficiency of cars and trucks by 25%.

Kyoto Forests? Fast-Growing Plantations are *Not* the Answer

There is increasing interest in meeting some portion of Canada’s Kyoto commitment through “afforestation”, or creating new forests for the purposes of sequestering carbon emissions. In particular, some are pressing for government programs to support the establishment of plantations of fast-growing species. However many experts have expressed strong skepticism about the advisability of such a scheme, citing a number of concerns.

The Kyoto Debate: Separating rhetoric from reality

by Elizabeth May, December 2002

America’s Gas Tank: The High Cost of Canada’s Oil and Gas Export Strategy

A report by the Natural Resources Defense Council and the Sierra Club of Canada, October 2002 *(pdf file, 660K)*

Over the past decade, surging demand from the United States for Canadian fossil fuels has coincided with deregulation of the energy industry and increasing control of Canadian energy companies by U.S. interests. The resulting oil and gas free-for-all in Canada is causing profound environmental problems, all in the service of turning Canada into America’s gas tank.

Ten Popular Myths About the Kyoto Protocol
Beginning with the myth that Canada's economy will suffer

Ten Popular Myths about Global Climate Change
Beginning with the myth that there is no scientific consensus

Climate Change Archives

- Climate skeptic misinterprets global warming, March 2002
- Kyoto Protocol to the United Nations Framework Convention on Climate Change
- Delegation Report -- Kyoto
- Draft Rational Energy Program 1998
- Rational Energy Program Highlights
- Rational Energy Program 1996 Media Release
- Particulate Matter, Ground-Level Ozone, and the Canada-Wide Standards Regulatory Process, 1999
- Emissions: the 3 E's
- Differentiation mythmaking busted
- The Net Approach -- the Great Carbon Scam
- Canada's CO2 emmissions take leap forward in 1996
- Delegation Report AGBM7
- Evaluation - Canada: AGBM7, July 1997
- Emissions by Country
- Impact of Increased Utilization of Ontario Hydro's Fossil Fuel Plants
- It's time for the federal government to walk the talk
- Forest Fires and Climate Change
- Protecting the Climate - what you can do
- Climate Change Fact Sheet - 1996

Sierra Club of Canada National Office
info@sierraclub.ca

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Global Warming

If some environmentalists are to be believed, we are on the verge of massive global climate change which will see a significant rise in sea levels, chaotic weather patterns, and catastrophic droughts all caused by small increase in global average temperature.

This site provides links to resources skeptical of those sort of doomsday scenarios. The articles linked to here are written by a wide variety of people, from scientists to laypeople, and their inclusion here should not be read as an endorsement of their positions.

Just as when dealing with things coming out of the environmentalist camp, you need to use your brain and decide for yourself to what extent global warming poses a threat to humanity.

Articles about global warming on this site:

- Ross Gelbspan's Pulitzer Prize (1/22/2004)
- *New York Times* Screws Up Correction of Global Warming Story (7/16/2002)
- New York Times Leads in Global Warming Nonsense (7/10/2002)
- Coloring the Debate Over Global Warming (7/2/2002)
- Typical Al Gore Nonsense on Global Warming (5/14/2002)
- Tuvalu Is Not Sinking (3/28/2002)
- Climate Change During Medieval Warm Period Very Similar to 20th Century Rise in Temperature (3/24/2002)
- Global Warming Shatters Reporter's Abilities to Do Simple Math (3/21/2002)
- NBC's Dishonest Coverage of Glacier National Park (10/3/2001)

- Richard Lindzen on the NAS Global Warming Report (6/27/2001)
- Does CO2 Lead to Global Warming or Vice Versa (6/21/2001)
- Does NAS Report Put Bush on the Hot Spot with Global Warming? (6/14/2001)
- The Problem with Media Coverage of Global Warming (4/19/2001)
- Does Global Warming Necessarily Mean More Disease? (4/12/2001)
- A Leftist Opposed to the Global Warming Treaty (11/8/2000)
- Feeling the Heat (10/31/2000)
- What Is Stephen Hawking Talking About? (10/3/2000)

Articles about global warming on other sites:

Basic introduction to global warming

- The coming climate - an excellent overview of global warming claims from Scientific American.
- globalwarming.com - lots of information critical of global warming claims
- Instant Expert Guide to Global Warming from the Heartland Institute
- Long Hot Year: Latest Science Debunks Global Warming Hysteria by Patrick J. Michaels
- Questions People Ask About Climate Change by Kenneth Green, D.Env.
- Still waiting for greenhouse - well designed with lots of easy to understand graphics
- World Climate Report - a comprehensive resource taking a skeptical look at global warming research and claims.

The Scientific Controversy

- Is tere a scientific consensus about global warming?
- Is there a scientific consensus on global warming?
- How accurate are warming predictions?
- Where are global temperatures headed?
- Is global warming causing extreme weather?

- Will global warming cause sea levels to rise?
- Could global warming be good for us?

The Political Controversy

- **The Kyoto Treaty**
- **Media Coverage of Global Warming**

Uncategorized links

- Holes in the greenhouse effect by Patrick J. Michaels
- Cool climate...hot politics by Jonathan H. Adler
- Stay cool from *The Economist*
- Avoiding global warming John McCarthy
- Global warming: bad science
- Global warming: inventing an apocalypse by Kevin McFarlane
- Global Warming Politics
- Patrick Michaels testifies before the House Subcommittee on Energy and Environment of the Committee on Science by Patrick Michaels
- http://www.junkscience.com/news/sun.html
- Oz greenhouse sceptic
- http://www.heartland.org/gray-study.htm
- http://www.his.com/~sepp
- http://www.junkscience.com/news/taubes2.html
- Global Politics, Political Warming
- The Heated Rhetoric of Global Warming by Jerry Taylor
- Holes in the Greenhouse Effect? by Patrick J. Michaels
- Manmade Global Warming? by Steve Milloy
- "Listen to the Rhythm "... of the Wobbling Sun? by Steve Milloy
- A Flash of Light in the Darkness by Steve Milloy
- Damn the Science, Full Speed Ahead by Steve Milloy
- Tree Ring Circus by Steve Milloy
- Global Warming Meltdown? by Steve Milloy

- More Hot Air Over Global Warming by Steve Milloy
- Global Warming, Asteroids and!The Washington Qost by Steve Milloy>/li>
- True Confessions (Global Warming-Style) by Steve Milloy !
- Global Warming's Dirty Little Secret by Patrick Michaels
- The Lethal Hot Air of Summer by Patrick J. Michaels "
- Administration Attempts Shoot-Down of Satellite by Patrick J. Michaels
- Fighting Fire With Facts by Patrick J. Michaels "
- Logic Goes Extinct as Planet Warms by Patrick J. Michaels "
- Sun to Blame for Global Warming by John Carlisle
- Global warming - is the Sun to blame? from The BBC "
- Blazing hot from The *New Scientist*
- Why So Hot? Don't Blame Man, Blame the Sun by Sallie Baliunas
- Global warming whining by Fred Singer
- Hot enough for you? by Tim Patterson and Tom Harris
- The Uncertainty Principle from The *Detroit News*
- Scientific Responsibility in Global Climate Change Research by S. Ichtiaque Rasool
- Back-tracking, arm-twisting pervade Bonn global warming meeting by Dave Gorak
- Arctic Melts While Logic Fiddles by Patrick J. Michaels (CATO Institute)
- Global Warming? from the Detroit News
- NET launches misinformation campaign by S. Fred Singer

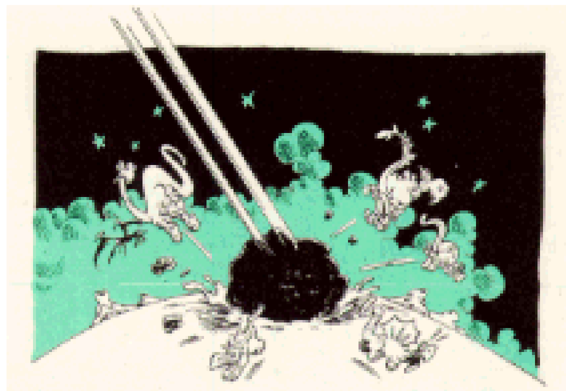
Discuss (1 Replies) | Printer Friendly

SEARCH GO

BEGINNERS GUIDE TO THE CONVENTION

Understanding Climate Change:
A Beginner's Guide to the UN Framework Convention

Introduction: A giant asteroid could hit the earth! Something else could happen! The global temperature could rise! Wake up!

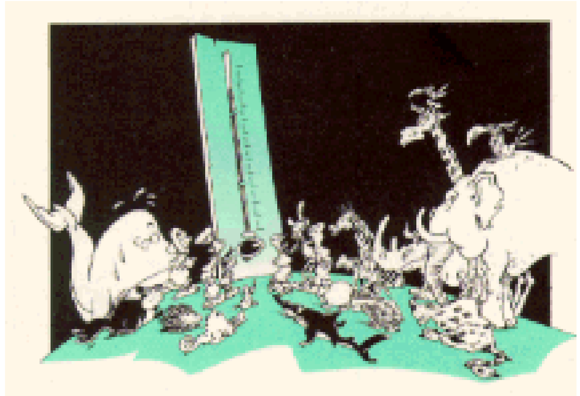


The 1990s have been a time of international soul- searching about the environment. What are we doing to our planet? More and more, we are realising that the Industrial Revolution has changed forever the relationship between humanity and nature. There is real concern that by the middle or the end of the next century human activities will have changed the basic conditions that have allowed life to thrive on earth.

The 1992 **United Nations Framework Convention on Climate Change** is one of a series of recent agreements through which countries around the world are banding together to meet this challenge. Other treaties deal with such matters as pollution of the oceans, expanding deserts, damage to the ozone layer, and the rapid extinction of plant and animal species. The Climate Change Convention focuses on something particularly disturbing: we are changing the way energy from the sun interacts with and escapes from our planet's atmosphere. By doing that, we risk altering the global climate. Among the expected consequences are an increase in the average temperature of the earth's surface and shifts in world-wide weather patterns. Other -- unforeseen -- effects cannot be ruled out.

We have a few problems to face up to.

Problem No. 1 (the big problem): Scientists see a real risk that the climate will change rapidly and dramatically over the coming decades and centuries. Can we handle it?



A giant asteroid did hit the earth -- about 65 million years ago. Splat. Scientists speculate that the collision threw so much dust into the atmosphere that the world was dark for three years. Sunlight was greatly reduced, so many plants could not grow, temperatures fell, the food chain collapsed, and many species, including the largest ever to walk the earth, died off.

That, at least, is the prevailing theory of why the dinosaurs became extinct. Even those who weren't actually hit by the asteroid paid the ultimate price.

The catastrophe that befell the dinosaurs is only one illustration, if dramatic, of how changes in climate can make or break a species.

According to another theory, human beings evolved when a drying trend some 10 million years ago was followed around three million years ago by a sharp drop in world temperature. The ape-like higher primates in the Great Rift Valley of Africa were used to sheltering in trees, but, under this long-term climate shift, the trees were replaced with grassland. The 'apes' found themselves on an empty plain much colder and drier than what they were used to, and extremely vulnerable to predators.

Extinction was a real possibility, and the primates appear to have responded with two evolutionary jumps -- first to creatures who could walk upright over long distances, with hands free for carrying children and food; and then to creatures with much larger brains, who used tools and were omnivorous (could eat both plants and meat). This second, large-brained creature is generally considered to be the first human.

Shifts in climate have shaped human destiny ever since, and people have largely responded by adapting, migrating, and growing smarter. During a later series of ice ages, sea levels dropped and humans moved across land bridges from Asia to the Americas and the Pacific islands. Many subsequent migrations, many innovations, many catastrophes have followed. Some can be traced to smaller climatic fluctuations, such as a few decades or centuries of slightly higher or lower temperatures, or extended droughts. Best known is the Little Ice Age that struck Europe in the early Middle Ages, bringing famines, uprisings, and the withdrawal of northern colonies in Iceland and Greenland. People have suffered under the whims of climate for millennia, responding with their wits, unable to influence these large events.

Until now. Ironically, we humans have been so remarkably successful as a species that we may have backed ourselves into a corner. Our numbers have grown to the point where we have less room for large-scale migration should a major climate shift call for it. And the products of our large brains -- our industries, transport, and other activities -- have led to something unheard of in the past. Previously the global climate changed human beings. Now human beings seem to be changing the global climate. The results are uncertain, but if current predictions prove correct, the climatic changes over the coming century will be larger than any since the dawn of human civilisation.

The principal change to date is in the earth's atmosphere. The giant asteroid that felled the dinosaurs threw large clouds of dust into the air, but we are causing something just as profound if more subtle. We have changed, and are continuing to change, the balance of gases that form the atmosphere. This is especially true of such key "greenhouse gases" as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). (Water vapour is the most important greenhouse gas, but human activities do not affect it directly.) These naturally occurring gases make up less than one tenth of one per cent of the total atmosphere, which consists mostly of oxygen (21 per cent) and nitrogen (78 per cent). But greenhouse gases are vital because they act like a blanket around the earth. Without this natural blanket the earth's surface would be some 30 C colder than it is today.

The problem is that human activity is making the blanket "thicker". For example, when we burn coal, oil, and natural gas we spew huge amounts of carbon dioxide into the air. When we destroy forests the carbon stored in the trees escapes to the atmosphere. Other basic activities, such as raising cattle and planting rice, emit methane, nitrous oxide, and other greenhouse gases. If emissions continue to grow at current rates, it is almost certain that atmospheric levels of carbon dioxide will double from pre-industrial levels during the 21st century. If no steps are taken to slow greenhouse gas emissions, it is quite possible that levels will triple by the year 2100.

The most direct result, says the scientific consensus, is likely to be a "global warming" of 1.5 to 4.5 C over the next 100 years. That is in addition to an apparent temperature increase of half a degree Centigrade since the pre-industrial period before 1850, at least some of which may be due to past greenhouse gas emissions.

Just how this would affect us is hard to predict because the global climate is a very complicated system. If one key aspect -- such as the average global temperature -- is altered, the ramifications ripple outward. Uncertain effects pile onto uncertain effects. For example, wind and rainfall patterns that have prevailed for hundreds or thousands of years, and on which millions of people depend, may change. Sea-levels may rise and threaten islands and low-lying coastal areas. In a world that is increasingly crowded and under stress -- a world that has enough problems already -- these extra pressures could lead directly to more famines and other catastrophes.

While scientists are scrambling to understand more clearly the effects of our greenhouse gas emissions, countries around the globe recently joined together to confront the problem.

How the Convention responds

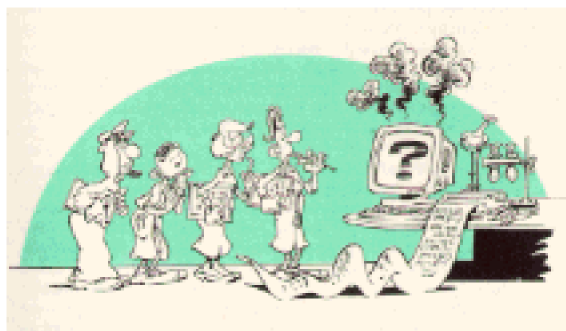
-- It recognises that there is a problem. That's a significant step. It is not easy for the nations of the world to agree on a common course of action, especially one that tackles a problem whose consequences are uncertain and which will be more important for our grandchildren than for the present generation. Still, the Convention was negotiated and signed by 165 states in a little over two years, and over 100 have already ratified and so are legally bound by it. The treaty took effect on 21 March 1994.

-- It sets an "ultimate objective" of stabilising "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system." The objective does not specify what these concentrations should be, only that they be at a level that is not dangerous. This acknowledges that there is currently no scientific certainty about what a dangerous level would be. Scientists believe it will take about another decade (and the next generation of supercomputers) before today's uncertainties (or many of them) are significantly reduced. The Convention's objective thus remains meaningful no matter how the science evolves.

-- It directs that "such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." This highlights the main concerns about food production -- probably the most climate-sensitive human activity -- and economic development. It also suggests (as most climatologists believe) that some change is inevitable and that adaptive as well as preventive measures are called for.

Again, this leaves room for interpretation in the light of scientific findings and the trade-offs and risks that the global community is willing to accept.

Problem No. 2: If the consequences of a problem are uncertain, do you ignore the problem or do you do something about it anyway?



Climate change is a threat to mankind. But no one is certain about its future effects or their severity. Responding to the threat is expected to be expensive, complicated, and difficult. There is even some disagreement over whether any problem exists at all: while many people worry that the effects will be extremely serious, others argue that scientists cannot prove that what they suspect will happen will actually happen. In addition, it is not clear who (in the various regions of the world) will suffer most. Yet if the nations of the world wait until the consequences and victims are clear, it will probably be too late to act. What should we do?

The truth is that in most scientific circles the issue is no longer whether or not climate change is a potentially serious problem. Rather, it is how the problem will develop, what its effects will be, and how these effects can best be detected. Computer models of something as complicated as the planet's climate system are not far enough advanced yet to give clear and unambiguous answers. Nevertheless, while the when, where, and how remain uncertain, the big picture painted by these climate models cries out for attention.

For example:

-- Regional rain patterns may change. At the global level, the evapo-transpiration cycle is expected to speed up. This means that it would rain more, but the rain would evaporate faster, leaving soils drier during critical parts of the growing season. New or worsening droughts, especially in poorer countries, could reduce supplies of clean, fresh water to the point where there are major threats to public health. Because they still lack confidence in regional scenarios, scientists are uncertain about which areas of the world risk becoming wetter and which drier. But with global water resources already under severe strain from rapid population growth and expanding economic activity, the danger is clear.

-- Climate and agricultural zones may shift towards the poles. In the mid-latitude regions the shift is expected to be 200 to 300 kilometres for every degree Celsius of warming. Increased summer dryness may reduce mid- latitude crop yields by 10 to 30 per cent, and it is possible that today's leading grain-producing areas (such as the Great Plains of the United States) would experience more frequent droughts and heat waves. The poleward edges of the mid-latitude agricultural zones -- northern Canada, Scandinavia, Russia, and Japan in the northern hemisphere, and southern Chile and Argentina in the southern hemisphere -- might benefit from higher temperatures. However, in some areas rugged terrain and poor soil would prevent these countries from compensating for reduced yields in today's more productive areas. -

- Melting glaciers and the thermal expansion of sea water may raise sea levels, threatening low-lying coastal areas and small islands.

The global mean sea level has already risen by around 15 centimetres during the past century, and global warming is expected to cause a further rise of about 18 cm by the year 2030. If the current trend in greenhouse gas emissions continues, the rise could amount to 65 cm above current levels by the year 2100. The most vulnerable land would be the unprotected, densely populated coastal regions of some of the world's poorest countries. Bangladesh, whose coast is already prone to devastating floods, would be a likely victim, as would many small island states such as the Maldives.

These scenarios are alarming enough to raise concern, but too uncertain to enable governments to make many specific decisions about what to do. The picture is fuzzy. Some governments, beleaguered by other problems and responsibilities and bills to pay, understandably are tempted to do nothing at all. Maybe the threat will go away. Or someone else will deal with it. Maybe another giant asteroid will hit the earth. Who knows?

How the Convention responds

-- It establishes a framework and a process for agreeing to specific actions -- later. The diplomats who wrote the Framework Convention on Climate Change saw it as a launching pad for potential further action in the future. They recognised that it would not be possible in the year 1992 for the world's governments to agree on a detailed blueprint for tackling climate change. But by establishing a framework of general principles and institutions, and by setting up a process through which governments can meet regularly, they got things started.

A key benefit of this approach is that it allows countries to begin discussing an issue even before they all fully agree that it is, in fact, a problem. Even sceptical countries feel it is worthwhile participating. (Or, to put it another way, they'd feel uneasy about being left out.) This creates legitimacy for the issue, and a sort of international peer pressure to take the subject seriously.

The Convention is designed to allow countries to weaken or strengthen the treaty in response to new scientific developments. For example, they can agree to take more specific actions (such as reducing emissions of greenhouse gases by a certain amount) by adopting "amendments" or "protocols" to the Convention.

The treaty promotes action in spite of uncertainty on the basis of a recent development in international law and diplomacy called the "precautionary principle." Under traditional international law, an activity generally has not been restricted or prohibited unless a direct causal link between the activity and a particular damage can be shown. But many environmental problems, such as damage to the ozone layer and pollution of the oceans, cannot be confronted if final proof of cause and effect is required. In response, the international community has gradually come to accept the precautionary principle, under which activities that threaten serious or irreversible damage can be restricted or even prohibited before there is absolute scientific certainty about their effects.

-- The Convention takes preliminary steps that clearly make sense for the time being. Countries ratifying the Convention -- called "Parties to the Convention" in diplomatic jargon -- agree to take climate change into account in such matters as agriculture, energy, natural resources, and activities involving sea-coasts. They agree to develop national programmes to slow climate change. The Convention encourages them to share technology and to cooperate in other ways to reduce greenhouse gas emissions, especially from energy, transport, industry, agriculture, forestry, and waste management, which together produce nearly all greenhouse gas emissions attributable to human activity.

-- The Convention encourages scientific research on climate change. It calls for data gathering, research, and climate observation, and it creates a "subsidiary body" for "scientific and technological advice" to help governments decide what to do next. Each country that is a Party to the Convention must also develop a greenhouse gas "inventory" listing its national sources (such as factories and transport) and "sinks" (forests and other natural ecosystems that absorb greenhouse gases from the atmosphere). These inventories will have to be updated regularly and made public. The information they provide on which activities emit how much of each gas will be essential for monitoring changes in emissions and determining the effects of measures taken to control emissions.

Problem No. 3: It's not fair.

If a giant asteroid hits the earth, that's nobody's fault. The same cannot be said for global warming.

There is a fundamental unfairness to the climate change problem that chafes at the already uneasy relations between the rich and poor nations of the world. Countries with high standards of living are mostly (if unwittingly) responsible for the rise in greenhouse gases. These early industrialisers -- Europe, North America, Japan, and a few others -- created their wealth in part by pumping into the atmosphere vast amounts of greenhouse gases long before the likely consequences were understood. Developing countries now fear being told that they should curtail their own fledgling industrial activities -- that the atmosphere's safety margin is all used up.

Because energy-related emissions are the leading cause of climate change, there will be growing pressure on all countries to reduce the amounts of coal and oil they use. There also will be pressure (and incentives) to adopt advanced technologies so that less damage is inflicted in the future. Buying such technologies can be costly.

Countries in the early stages of industrialisation -- countries struggling hard to give their citizens better lives -- don't want these additional burdens. Economic development is difficult enough already. If they agreed to cut back on burning the fossil fuels that are the cheapest, most convenient, and most useful for industry, how could they make any progress?

There are other injustices to the climate change problem. The countries to suffer the most if the predicted consequences come about -- if agricultural zones shift or sea levels rise or rainfall patterns change -- will probably be in the developing world. These nations simply do not have the scientific or economic resources, or the social safety nets, to cope with disruptions in climate. Also, in many of these countries rapid population growth has pushed many millions of people onto marginal land -- the sort of land that can change most drastically due to variations in climate.

How the Convention responds

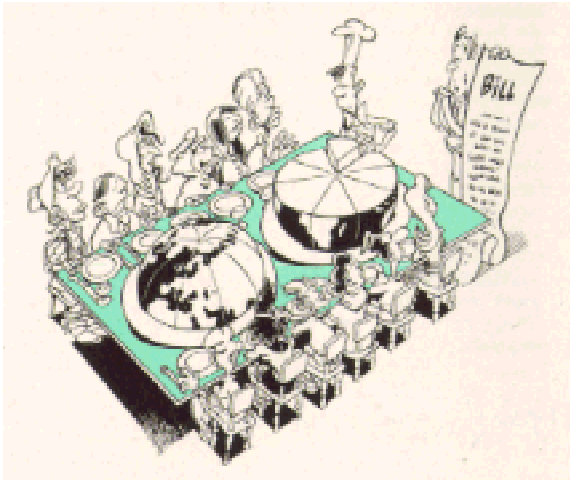
-- It puts the lion's share of the responsibility for battling climate change -- and the lion's share of the bill -- on the rich countries. The Convention notes that the largest share of historical and current emissions originates in developed countries. Its first basic principle is that these countries should take the lead in combating climate change and its adverse impacts. Specific commitments in the treaty relating to financial and technological transfers apply only to the 24 developed countries belonging to the Organisation for Economic Cooperation and Development (OECD -- excepting Mexico, which joined the OECD in 1994). They agree to support climate change activities in developing countries by providing financial support above and beyond any financial assistance they already provide to these countries.

Specific commitments concerning efforts to limit greenhouse gas emissions and enhance natural sinks apply to the OECD countries as well as to 12 "economies in transition" (Central and Eastern Europe and the former Soviet Union). Although negotiations left the treaty language less than clear, it is generally accepted that the OECD and transition countries should at a minimum seek to return by the year 2000 to the greenhouse gas emission levels they had in 1990.

-- The Convention recognises that poorer nations have a right to economic development. It notes that the share of global emissions of greenhouse gases originating in developing countries will grow as these countries expand their industries to improve social and economic conditions for their citizens.

-- It acknowledges the vulnerability of poorer countries to the effects of climate change. One of the Convention's basic principles is that the specific needs and circumstances of developing countries should be given "full consideration" in any actions taken. This applies in particular to those whose fragile ecosystems are highly vulnerable to the impacts of climate change. The Convention also recognises that states which depend on income from coal and oil would face difficulties if energy demand changes.

Problem No. 4: If the whole world starts consuming more and living the good life, can the planet stand the strain?



As the human population continues to grow, the demands human beings place on the environment increase. The demands are becoming all the greater because these rapidly increasing numbers of people also want to live better lives. More and better food, more and cleaner water, more electricity, refrigerators, automobiles, houses and apartments, land on which to put houses and apartments . . .

Already there are severe problems supplying enough fresh water to the world's billions. Burgeoning populations are draining the water from rivers and lakes, and vast underground aquifers are steadily being depleted. What will people do when these natural "tanks" are empty? There are also problems growing and distributing enough food -- widespread hunger in many parts of the world attests to that. There are other danger signals. The global fish harvest has declined sharply; as large as the oceans are, the most valuable species have been effectively fished out.

Global warming is a particularly ominous example of humanity's insatiable appetite for natural resources. During the last century we have dug up and burned massive stores of coal, oil, and natural gas that took millions of years to accumulate. Our ability to burn up fossil fuels at a rate that is much, much faster than the rate at which they were created has upset the natural balance of the carbon cycle. The threat of climate change arises because one of the only ways the atmosphere -- also a natural resource -- can respond to the vast quantities of carbon being liberated from beneath the earth's surface is to warm up.

Meanwhile, human expectations are not tapering off. They are increasing. The countries of the industrialised "North" have 20 per cent of the world's people but use about 80 per cent of the world's resources. By global standards, they live extremely well. It's nice living the good life, but if everyone consumed as much as the North Americans and Western Europeans consume -- and billions of people aspire to do just that -- there probably would not be enough clean water and other vital natural resources to go around. How will we meet these growing expectations when the world is already under so much stress?

How the Convention responds

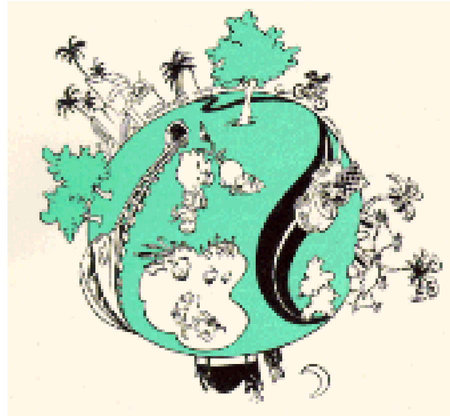
-- It supports the concept of "sustainable development." Somehow, mankind must learn how to alleviate poverty for huge and growing numbers of people without destroying the natural environment on which all human life depends. Somehow a way has to be found to develop economically in a fashion that is sustainable over a long period of time. The buzzword for this challenge among environmentalists and international bureaucrats is "sustainable development". The trick will be to find methods for living well while using critical natural resources at a rate no faster than that at which they are replaced. Unfortunately, the international community is a lot farther along in defining the problems posed by sustainable development than it is in figuring out how to solve them.

-- The Convention calls for developing and sharing environmentally sound technologies and know-how. Technology will clearly play a major role in dealing with climate change. If we can find practical ways to use cleaner sources of energy, such as solar power, we can reduce the consumption of coal and oil. Technology can make industrial processes more efficient, water purification more viable, and agriculture more productive for the same amount of resources invested. Such technology must be made widely available -- it must somehow be shared by richer and more scientifically advanced countries with poorer countries that have great need of it.

-- The Convention emphasises the need to educate people about climate change. Today's children and future generations must learn to look at the world in a different way than it has been looked at by most people during the 20th century. This is both an old and a new idea. Many (but not all!) pre-industrial cultures lived in balance with nature. Now scientific research is telling us to do much the same thing. Economic development is no longer a case of "bigger is better" -- bigger cars, bigger houses, bigger harvests of fish, bigger doses of oil and coal. We must no longer think of human progress as a matter of imposing ourselves on the natural environment. The world -- the climate and all living things -- is a closed system; what we do has consequences that eventually come back to affect us. Tomorrow's children -- and today's adults, for that matter -- will have to learn to think about the effects of their actions on the climate. When they make decisions as members of governments and businesses, and as they go about their private lives, they will have to take the climate into account.

In other words, human behaviour will have to change -- probably the sooner the better. But such things are difficult to prescribe and predict. There is, for example, the matter of what sacrifices might have to be made by everyone for the good of the global climate. That leads to...

Problem No. 5: Who has the energy, time, or money left to deal with climate change, when we have so many other problems?



A valid point.

How the Convention responds

-- It starts slowly. It doesn't make too many demands (or requests) for the time being. But stay tuned. The Framework Convention on Climate Change is a general treaty with just a few specific requirements. More and bigger requirements may come later, in the form of amendments and protocols. This will happen as scientific understanding of climate change becomes clearer and as the countries of the world, already suffering from a case of "disaster fatigue", adjust to the idea that they have yet another crisis to face and pay for. War, famine, AIDS, the ozone "hole", acid rain, the loss of ecosystems and species ... Thinking about these problems, people could be forgiven for wondering if they should throw in the towel.

We can't give up, of course. And while the Convention cannot claim to have the issue all sorted out, it does make a start. Things are beginning to happen. Developed countries are making national plans with the aim of returning their greenhouse gas emissions to 1990 levels by the year 2000 -- thereby reversing the historical trend of ever-increasing emissions. Countries that have ratified the treaty are beginning to gather data on their emissions and on the present climate. More and more, people and governments are talking and thinking about climate change.

What happens next? Step by step, national governments committed to controlling their emissions must begin tightening emissions standards and requiring more replanting of trees; some countries are already working on such standards. Local and urban governments -- which often have direct responsibility for transport, housing, waste management, and other greenhouse gas-emitting sectors of the economy -- have a role, too. They can start designing and building better public transport systems, for example, and creating incentives for people to use them rather than private automobiles. They should tighten construction codes so that new houses and office buildings can be heated or cooled with less fuel. Meanwhile, industrial companies need to start shifting to new technologies that use fossil fuels and raw materials more efficiently. Wherever possible they should switch to renewable energy sources such as wind and solar power. They should also redesign products such as refrigerators, automobiles, cement mixes, and fertilisers so that they produce lower greenhouse gas emissions. Farmers should look to technologies and methods that reduce the methane emitted by livestock and rice fields. Individual citizens, too, must cut their use of fossil fuels -- take public transport more often, switch off the lights in empty rooms -- and be less wasteful of all natural resources.

It may seem naive to expect behavioural changes of this magnitude. But the potential for more responsible behaviour on behalf of the climate is nevertheless there. It is possible that as time passes and more is known about the threats posed by climate change, such responses will seem a lot less naive and a lot more vital to humanity's well-being.

-- The Convention is based on sharing the burdens of coping with climate change. This is important. The atmosphere is a shared resource, part of the "global commons". The treaty tries to make sure that any sacrifices made in protecting this resource will be shared fairly among countries -- in accordance with their "common but differentiated responsibilities and respective capabilities and their social and economic conditions". This means, the participating countries hope, that whatever ultimately has to be done will be done by enough participants to make the benefits worth the sacrifices. It is easier to sacrifice towards the common good when you are sure everyone else is pitching in.

Conclusion: Into the 21st century and beyond Climate change would have lasting consequences. One giant asteroid came along 65 million years ago, and that was it for the dinosaurs.

In facing up to man-made climate change, human beings are going to have to think in terms of decades and centuries. The job is just beginning. Many of the effects of climate shifts will not be apparent for two or three generations. In the future, everyone may be hearing about -- and living with -- this problem.

The Framework Convention takes this into account. It is aimed at the next century as much as at this one. It establishes institutions to support efforts to carry out long-term commitments and to monitor long-term efforts to minimise -- and adjust to -- climate change. The Conference of the Parties, in which all states that have ratified the treaty are represented, is the Convention's supreme body. It meets for the first time in March 1995 and on a yearly basis thereafter. It will promote and review the implementation of the Convention and, if appropriate, strengthen it. The Conference of Parties will be assisted by two subsidiary bodies, one for scientific and technological advice and the other for implementation. The Conference of Parties may also make additional arrangements in the future to help support the needs of the Convention.

The treaty also reflects a reasonable view about how the world will function politically in the future, and assumptions about how problems can best be solved over the next century. It is based on a cooperative rather than a confrontational approach -- it assumes that countries can successfully tackle problems such as climate change only if they work together as a team. And it is designed to work well in a multi-polar world in which many countries have influence and the power to apply peer pressure to persuade others to uphold their obligations.

How can we strike a balance with the environmental conditions that allow us to exist in the first place? That is a question humankind has largely ignored up to now, at its peril. From here on it is a challenge we probably will have to face as long as our species exists.

BOX: What is the greenhouse effect?

In the long term, the earth must shed energy into space at the same rate at which it absorbs energy from the sun. Solar energy arrives in the form of short-wavelength radiation. Some of this radiation is reflected away by the earth's surface and atmosphere. Most of it, however, passes straight through the atmosphere to warm the earth's surface. The earth gets rid of this energy (sends it back out into space) in the form of long- wavelength, infra-red radiation.

Most of the infra-red radiation emitted upwards by the earth's surface is absorbed in the atmosphere by water vapour, carbon dioxide, and the other naturally occurring "greenhouse gases". These gases prevent energy from passing directly from the surface out into space. Instead, many interacting processes (including radiation, air currents, evaporation, cloud-formation, and rainfall) transport the energy high into the atmosphere. From there it can radiate into space. This slower, more indirect process is fortunate for us, because if the surface of the earth could radiate energy into space unhindered, the earth would be a cold, lifeless place -- a bleak and barren planet rather like Mars.

By increasing the atmosphere's ability to absorb infra-red energy, our greenhouse gas emissions are disturbing the way the climate maintains this balance between incoming and outgoing energy. A doubling of the concentration of long-lived greenhouse gases (which is projected to occur early in the next century) would, if nothing else changed, reduce the rate at which the planet can shed energy into space by about 2 per cent. Energy cannot simply accumulate. The climate somehow will have to adjust to get rid of the extra energy -- and while 2 per cent may not sound like much, over the entire earth that amounts to trapping the energy content of some 3 million tons of oil every minute.

Scientists point out that we are altering the energy "engine" that drives the climate system. Something has to change to absorb the shock.

Published by the UNEP/WMO Information Unit on Climate Change. Printed in December 1994. For more information, contact UNEP/IUC, Geneva Executive Center, Box 356, 1219 Châtelaine, Switzerland

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CLIMATE CHANGE INFORMATION KIT

Table of contents

The entire information kit can be downloaded in PDF. In English (new 2002 version), French (2001 version), German (1999 version). The sheets posted in HTML below were updated in July 2002.

Understanding the climate system

Facing the consequences

The Climate Change Convention

Limiting greenhouse gas emissions

Facts and figures

Updated in July 2002 based on the IPCC's "Climate Change: 2001" assessment report and current activities under the UN Framework Convention on Climate Change. Published by the United Nations Environment Programme and sponsored by UNEP, the UN Development Programme, the UN Department of Economic and Social Affairs, the UN Institute for Training and Research, the World Meteorological Organization, the World Health Organization, and the Climate Change Secretariat (UNFCCC). Edited by Michael Williams. For additional copies, please contact UNEP's Information Unit for Conventions, International Environment House (Geneva), 15 chemin des Anémones, 1219 Châtelaine, Switzerland; tel. (+41-22) 917-8244/8196/8242; fax (+41-22) 797 3464; e-mail iuc@unep.ch. Also available at www.unep.ch/conventions

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THE CONVENTION AND KYOTO PROTOCOL

The United Nations Framework Convention on Climate Change
Guide Books

Text of the Convention

(pdf) English Arabic Français Deutsch Russian Español

(html) English as a single document , or by Articles

Status of Signatories & Ratification of the Convention

The text of the Convention was adopted at the United Nations Headquarters, New York on the 9 May 1992; it was open for signature at the Rio de Janeiro from 4 to 14 June 1992, and thereafter at the United Nations Headquarters, New York, from 20 June 1992 to 19 June 1993. By that date the Convention had received 166 signatures. The Convention entered into force on 21 March 1994. Those States that have not signed the Convention may accede to it at any time.

For those States that ratify, accept or approve the Convention or accede thereto after the date of entry into force, the Convention shall enter into force on the ninetieth day after the date of the deposit by such State of its instrument of ratification, acceptance, approval or accession.

The list below contains the latest information concerning dates of signature and ratification received from the Secretary-General of the United Nations, as Depository of the Convention. The dates in the column entitled "date of ratification" are those of the receipt of the instrument of ratification **(R)**, acceptance **(At)**, approval **(Ap)** or accession **(Ac).**
(For an explanation of these legal terms, please follow this link)

List of Signatories & Ratification of the Convention (Parties in chronological order (pdf) as of 24 May 2004. The Convention currently has received 189 instruments of ratification.

The Kyoto Protocol
The Kyoto "thermometer": measuring progress toward entry in to force

Kyoto Protocol Introduction text

Text of the Kyoto Protocol

(pdf) English Arabic Chinese Français Russian Español

(html) English

Status of the Kyoto Protocol

The text of the Protocol to the UNFCCC was adopted at the third session of the Conference of the Parties to the UNFCCC in Kyoto, Japan, on 11 December 1997; it was open for signature from 16 March 1998 to 15 March 1999 at United Nations Headquarters, New York. By that date the Protocol had received 84 signatures. Those Parties that have not yet signed the Kyoto Protocol may accede to it at any time.

The Protocol is subject to ratification, acceptance, approval or accession by Parties to the Convention. It shall enter into force on the ninetieth day after the date on which not less than 55 Parties to the Convention, incorporating Annex I Parties which accounted in total for at least 55 % of the total carbon dioxide emissions for 1990 from that group, have deposited their instruments of ratification, acceptance, approval or accession.

The list below contains the latest information concerning dates of signature and ratification received from the Secretary-General of the United Nations, as Depository of the Kyoto Protocol. The dates in the column entitled "date of ratification" are those

of the receipt of the instrument of ratification **(R)**, acceptance **(At)**, approval **(Ap)** or accession **(Ac).**
(For an explanation of these legal terms, please follow this link)

List of Signatories & Ratification to the Kyoto Protocol, Parties in alphabetical order (pdf) as at 29 July 2004, 84 Parties have signed and 124 Parties have ratified or acceded to the Kyoto Protocol.

Guide Books

Caring for climate
A guide to the Climate Change Convention and the Kyoto Protocol (UNFCCC)

- (pdf) English Español

- **Guide to the climate change process** (UNFCCC)
preliminary version

- 
Reporting on Climate Change
User manual for the guidelines on national communications from non-Annex I Parties

(pdf) English Français Español

- **Beginner's guide to the convention** (UNFCCC/UNEP)
(pdf) English (2002) Français (2002) Español (2002) Deutsch (2001)
(html) English (2001)

- **Climate change information kit** (UNFCCC/UNEP)
(pdf) English (2002) Français (2001) Español (courtesy of the Govt. of Uruguay) Deutsch (2001) Russian (2003)
(html) English (2002)

- **Counting emissions and removals**
Greenhouse gas inventories under the UNFCCC

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CONVENTION PARTIES AND OBSERVERS

National focal point - html - pdf

List of countries in alphabetical order

A B C D E F G H-I J K L M N O-P-Q R S T U V-W-X Y-Z - IGOs - NGOs

Afghanistan
Albania
Algeria
Andorra
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria
Azerbaijan

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Bahamas
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi

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Cambodia
Cameroon
Canada
Cape Verde
Central African Republic
Chad
Chile
China
Colombia
Comoros
Congo
Cook Islands
Costa Rica
Côte d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic

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Uganda
Ukraine
United Arab Emirates
United Kingdom of Great Britain and Northern Ireland
United Republic of Tanzania
United States of America
Uruguay
Uzbekistan

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Vanuatu
Venezuela
Viet Nam
Yemen

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Zambia
Zimbabwe

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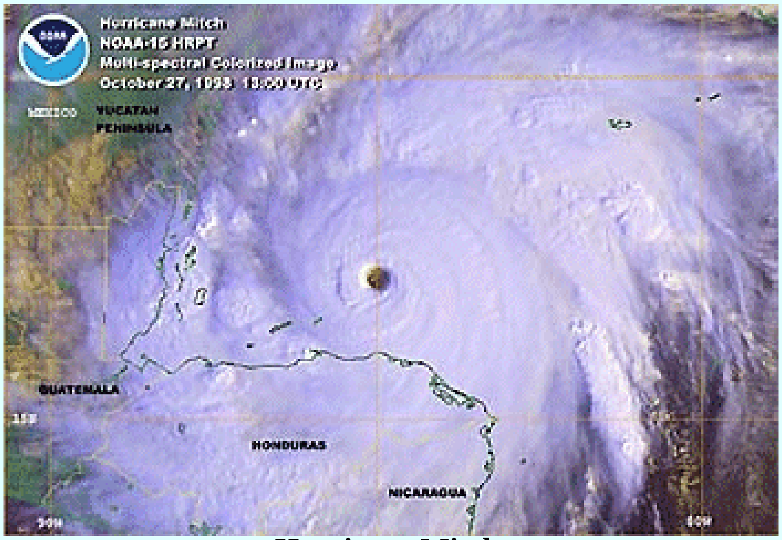
Hurricanes

Updated 27 May 2004



Hurricane Mitch

Note: The most recent update includes a map for the 1950-2003 period. Also, please check NOAA's National Hurricane Center web site for other maps and information.

Small--for a quick view, Large--larger image for printing

NEW

1950-2003 U.S. Landfalling Hurricanes--JPEG Maps

(small) (large)

1901-2003 U.S. Landfalling Hurricanes (GIF & JPEG Maps):

	1901-1920	1921-1940	1941-1960	1961-1980	1981-1996	1950-2003
Atlantic & Gulf of Mexico	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large

Small--for a quick view, Large--larger image for printing

1899-1996 U.S. Landfalling Major Hurricanes--GIF Maps (small) (large)

Special Reports:

Hurricanes -- 2003

Hurricanes -- 2002

Hurricanes -- 2001

Hurricane Keith--October 2000
TS Helene and Gordon--September 2000
Hurricanes -- 2000
U.S. Wind Climatology (PDF format, includes wind gusts)

Atlantic Hurricane Season--1999 (Tech Report, PDF format)
Hurricanes -- 1999
Hurricane Lenny--November 1999
Hurricane Irene--October 1999
Hurricane Floyd--September 1999
Hurricane Dennis--August 1999
Hurricane Bret--August 1999

1998 Atlantic Tropical Storms
Saffir-Simpson Hurricane Scale
Category 5 MONSTERS (Chronology)
Normalized Hurricane Damages in the US (NOAA/NCAR report)
Hurricane Mitch--October 1998
Hurricane Georges--September 1998
Hurricane Bonnie--August 1998

Atlantic Hurricane Season--1997
Hurricane Danny--July 1997

Atlantic Hurricane Season--1996
Hurricane Fran--September 1996
Hurricane Bertha--July 1996
Hurricane Bertha--July 1996 (2nd report)

Atlantic Hurricane Season--1995
Hurricane Opal--October 1995

Tropical Storm Alberto Flooding--July 1994
Hurricane Andrew--August 1992
Unnamed Hurricane--October 1991 (Halloween Storm)
Hurricane Agnes--June 1972
Hurricane Camille--August 1969
Galveston Hurricane--September 1900

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The Canadian Hurricane Centre

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Welcome to the Canadian Hurricane Centre web site. Located in downtown Dartmouth, Nova Scotia; the hurricane centre specializes in providing information to Canadians on storms of tropical origin that affect Canada or its territorial waters. On this web site you will find the latest hurricane forecasts, hurricane storm summaries, along with a wide range of information related to the science of hurricanes.

Our Headlines Summer 2004

Hurricane Juan
Click here to read the Hurricane Juan special reports

Atlantic Hurricane Season 2004 Outlook

Once again experts around the world are predicting an above normal level of tropical cyclones in the Atlantic Ocean this year. This will make seven years in a row for a forecast of above-normal activity...and those forecasts have seldom been wrong. Learn More...

A Climatology of Hurricanes for Canada: Improving Our Awareness of the Threat

Here are some samples from the full climatology report that will be released later summer 2004. The full report will be produced on CD with more general pertinent information made available on this Web site.

2003 Tropical Cyclones Season Summary

A complete listing and summary of all the major tropical cyclones that occured in the Atlantic Ocean during the 2003 storm season.

Hurricane Juan

At 12:10 a.m. ADT, Monday September 29, 2003, Hurricane Juan made landfall in Nova Scotia as one of most powerful and damaging hurricanes to ever affect Canada. In response to the large demand for information, Environment Canada has created a comprehensive Hurricane Juan web site summarizing all aspects of the hurricane. The web site is updated regularly with new articles, summaries, maps, and photos.

Storm Links

- Hurricane and Tropical Storm Watches and Warnings- These bulletins (when issued) are located near the top of the weather warnings page.
- Hurricane Information Statements - A technical discussion of the storms tracked by the Canadian Hurricane Centre.
- Hurricane Track Information - Online map of the storms tracked by the Canadian Hurricane Centre.
- Latest Satellite Photo
- Latest Radar Image
- National Hurricane Center (U.S.)

Coming Summer 2004

The Canadian Hurricane Centre web site is currently being updated in time for the start of the 2004 Atlantic hurricane season. We are very excited about some of the new sections under construction as they will provide quality in depth information and new services for our web users.

Here is a preview of what is coming:

- GIS based hurricane track archive
- Hurricane products for handheld devices (cellphones/pda's).
- Hurricane alert email subscription service
- Remembering Hurricane Hazel 50 years later.

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DAILY LessonPlan

Developed in Partnership with the Bank Street College of Education in NYC

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Related Article
Hurricane Aims at Coast of Carolinas
By DAVID FIRESTONE

(Go to Article.)

Thursday, September 16, 1999

Counting on the Havoc of Hurricanes

Comparing Statistics of Hurricane Floyd to Other Recent Hurricanes: A Math Lesson

Author(s)
Katherine Schulten, The New York Times Learning Network
Alison Zimbalist, The New York Times Learning Network

Grades: 6-8, 9-12
Subjects: Mathematics, Science
Interdisciplinary Connections

Overview of Lesson Plan: In this lesson, students define and classify all the different ways in which numbers are used in forecasting and coping with the effects of a hurricane. They then conduct research to compare and contrast these numbers as they apply to Hurricane Floyd and other recent hurricanes. Finally, they graph their findings.
Review the Academic Content Standards related to this lesson.

Suggested Time Allowance: 1 hour

Objectives:
Students will:
1. List and define all the ways numbers are used in predicting and preparing for a hurricane, weathering it, and handling its aftermath.
2. Examine how Hurricane Floyd has affected the Eastern Coastal United States by reading "Hurricane Aims at Coast of Carolinas."
3. Classify hurricane-related numbers into statistical categories.
4. Research to find statistics as they apply to Hurricane Floyd and another recent hurricane.
5. Compare and contrast hurricanes by graphing statistical information.
6. Apply understanding of the use of mathematics with regards to hurricanes to continue to track Hurricane Floyd and other hurricanes this season.

Resources / Materials:
-pens/pencils
-classroom blackboard
-paper
-copy of "Hurricane Aims at Coast of Carolinas"
-computers with Internet access
-research materials about hurricanes (including textbooks, newspapers, and other weather references)
-graph paper (several sheets per student)

Activities / Procedures:
1. WARM-UP/DO-NOW: Ask the class to brainstorm as a group all the ways they can think of in which numbers might be used in describing hurricanes. (These include predicting, tracking, observing, and assessing hurricanes, as well as in coping with their aftermath. For example, measurement of different aspects of weather conditions like barometric pressure, wind, and rain; storm surveillance and assessment including things like size, speed, location, force, and path; and costs in

terms of deaths and injuries, populations, infrastructures, and businesses affected, as well as money allotted for clean-up.) Write all of students' ideas on the board.

2. As a class, read "Hurricane Aims at Coast of Carolinas." Students should circle any use of numbers they find as they read to add to the list on the board. Focus on the following questions for discussion:
a. Where has Hurricane Floyd already hit, and what have been the damages thus far?
b. How large and strong is Hurricane Floyd?
c. Where do storm-trackers anticipate Hurricane Floyd will hit, and when?
d. How have people taken precautions to protect themselves from this storm?
e. What different relief organizations are getting involved in helping those areas that have been and are anticipated to be hardest hit by this storm, and what are these organizations doing?
f. How has the government reacted to the hurricane?
g. How are different people reacting to the hurricane?
h. How does this hurricane compare to other large hurricanes in the recent past?

3. Have the class look again at the list they created on the board and categorize these numbers into different statistical areas (costs, population, sizes, etc.). This may be done individually or in small groups, but before moving on to the next step, categories should be shared and agreed upon as a whole class.

4. Divide the class into pairs and have each pair use the Internet and any other available classroom resources to find all the statistics they can about Hurricane Floyd and one other recent hurricane (for example, Hurricanes Andrew, Hugo, and Mitch). Try to assign a different hurricane to group with.

5. Have each pair create a series of graphs that show how Hurricane Floyd compares statistically to the other recent hurricane they have researched. Graphs should be posted around the room and statistics should be compared.

6. WRAP-UP/HOMEWORK: Students use their understanding of the mathematics involved in hurricane tracking by observing the path of Hurricane Floyd and comparing it to the predictions meteorologists made earlier. Students should create an ongoing list of statistics about this hurricane and create new graphs to track the damage of this storm.

Further Questions for Discussion:
--What is a hurricane and how does it differ from other types of storms?
--How do hurricanes form?
--How are hurricanes forecasted, and what surveillance methods are used to watch the progress of hurricanes?
--How can an area prepare for a hurricane?
--What aspects of a country's infrastructure may be affected by a hurricane or other natural disaster?
--What industries might be affected by major weather disasters?
--What government services offer financial help to areas affected by weather disasters? What other services can offer aid?
--Why do people often hesitate to leave an area where a hurricane is predicted to hit?

Evaluation / Assessment:
Students will be evaluated based on their participation in class discussions, thorough research, and creation of comparative graphs.

Vocabulary:
evacuation, emergency, widespread, hurricane, enormous, shelters, exodus, coastal, disrupted, estimated, congestion, incompetence, inundated, pier, predicted, saturated, ominous, abandoned, swells, facade, exterior, cyclones, ruinous, erosion

Extension Activities:
1. Create a chart that illustrates and explains each stage in the life-cycle of a hurricane.

2. Research the instruments meteorologists use to forecast and track hurricanes, then create a chart that explains how they do this.

3. Compile a series of statistics that chart the extreme weather conditions in the area where you live (for example, the most and least rain or snow, highest winds, lowest and highest temperatures, etc.).

4. Graph a comparison of Hurricane Floyd's devastation with that of the worst recent weather emergency or natural disaster in your own area.

5. Visit a local weather center and observe and interview meteorologists at work.

6. Continue to track hurricanes during the rest of this hurricane season using the statistical categories your class defined in this lesson. Post your findings on a class bulletin board.

7. Organize a community aid drive for the victims of Hurricane Floyd. Contact local relief agencies for support or to volunteer to participate in community efforts.

Interdisciplinary Connections:
American History**-** Hurricane Floyd has resulted in one of the most extensive evacuations ever conducted in the United States. Research other evacuations and compare and contrast them to this one. Have we learned from the past in improving the way such evacuations are conducted?
-Research other natural disasters on the scale of Hurricane Floyd to learn how relief organizations and government programs assisted the victims and helped to rebuild the land and communities.

Civics/Social Studies**-** Imagine that you are the mayor of a small coastal town directly in the path of Hurricane Floyd. What can you do insure the safety of your citizens as well as contain costs as much as possible? Brainstorm a list of possible solutions to this problem, and rank them in terms of what you would do first, second, third, etc.

Geography- Investigate how hurricanes and other natural disasters can devastate the elements of the infrastructure of an area, as well as the lives of its people by keeping a log of how Hurricane Floyd affects the areas it hits. Students can work in groups, each focusing on one aspect of the infrastructure (commerce/trade; food supply; health care/disease; communication/roads; shelter; and power) and making a list of problems you read about in this area. Then, each group should propose solutions to aid the devastation of these areas of the infrastructure.

Language Arts**-** Write a reflective essay about your reactions to Hurricane Floyd, perhaps prompted by photographs from the newspaper.
-Write an essay about the worst weather you have ever experienced, or write fictional stories imagining reactions to a natural disaster like Hurricane Floyd. (As models students might want to read other accounts, fictional or true, of such experiences. Chapter 18 of Zora Neale Hurston's novel Their Eyes Were Watching God, for example, tells the story of several characters fleeing a hurricane on foot.)

Media Studies**-** What are all the different aspects of this natural disaster that a newspaper must cover? Imagine that you are the editor of your local paper and must assign stories on the hurricane. What aspects should your paper cover, and why? Make a list, then check your local paper over the next several days to see how close your ideas were to what the paper actually covered.

Other Information on the Web
Florida Division of Emergency Management: Hurricane Floyd (http://www.dca.state.fl.us/eoc/) offers the latest situation reports and other information.

Hurricane Floyd Web Cams (http://www.earthcam.com/floyd/) show continuously updated live views from around the hurricane zone.

The National Weather Service (http://www.nws.noaa.gov/om/hurrbro.htm) provides current official weather warnings, observations, and forecasts.

The National Hurricane Center (http://www.nhc.noaa.gov/) maintains a continuous watch on tropical cyclones over the Atlantic, Caribbean, Gulf of Mexico, and the Eastern Pacific from May 15 through November 30, and issues watches, warnings, forecasts, and analyses of hazardous weather conditions in the tropics.

Hurricane and Storm Tracking, Atlantic and Pacific Oceans (http://hurricane.terrapin.com/) posts current advisories, bulletins, strike probabilities, storm positions, and animated storm movement plots.

Are You Ready for a Hurricane? (http://www.redcross.org/disaster/safety/hurrican.html) is advice from the American Red Cross on what to do in the event of a hurricane threat.

Hurricane: Storm Science (http://www.miamisci.org/hurricane) helps you understand hurricanes from the inside out, including survivors' stories, making a weather station, and contributing your own natural disaster stories to the Healing Quilt.

The American Red Cross (http://www.redcross.org) is a humanitarian organization that has helped over 30 million people each year prevent, prepare for and cope with emergencies.

Academic Content Standards:

This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8
Mathematics Standard 1- Uses a variety of strategies in the problem-solving process. Benchmarks: Represents problem situations in and translates among oral, written, concrete, pictorial, and graphical forms; Understands the role of written symbols in representing mathematical ideas and the use of precise language in conjunction with the special symbols of mathematics
Connect to State Standard
Mathematics Standard 4- Understands and applies basic and advanced properties of the concepts of measurement. Benchmarks: Understands the basic concept of rate as a measure; Solves problems involving units of measurement and converts answers to a larger or smaller unit within the same system; Understands the concepts of precision and significant digits as they relate to measurement; Selects and uses appropriate units and tools, depending on degree of accuracy required, to find measurements for real-world problems.
Connect to State Standard
Mathematics Standard 6- Understands and applies basic and advanced concepts of statistics and data analysis. Benchmarks: Understands basic characteristics of measures of central tendency; Understands the basic concepts of center and dispersion of data; Reads and interprets data in charts, tables, plots, and graphs; Uses data and statistical measures for a variety of purposes; Organizes and displays data using tables, graphs, frequency distributions, and plots; Understands that the same set of data can be represented using a variety of tables, graphs, and symbols and that different modes of representation often convey different messages
Connect to State Standard
Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows factors that can impact the Earth's climate; Knows the processes involved in the water cycle.
Connect to State Standard

Grades 9-12
Mathematics Standard 1- Uses a variety of strategies in the problem-solving process. Benchmarks: Uses formal mathematical language and notation to represent ideas, to demonstrate relationships within and among representation systems, and to formulate generalizations; Understands the components of mathematical modeling

Connect to State Standard

Mathematics Standard 4- Understands and applies basic and advanced properties of the concepts of measurement. Benchmarks: Solves problems involving rate as a measure; Understands the concepts of absolute and relative errors in measurement; Selects and uses an appropriate direct or indirect method of measurement in a given situation; Solves real-world problems involving three-dimensional measures

Connect to State Standard

Mathematics Standard 6- Understands and applies basic and advanced concepts of statistics and data analysis. Benchmarks: Selects and uses the best method of representing and describing a set of data; Understands measures of central tendency and variability and their applications to specific situations

Connect to State Standard

Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows that weather and climate involve the transfer of energy in and out of the atmosphere; Knows how winds and ocean currents are produced on Earth's surface

Connect to State Standard

Send feedback on this lesson.

Browse or search the lesson plan archive.

Create an Art Object Depicting a Hurricane

Topic: Hurricanes

Grade Level: Third and Fourth

To the Teacher: This is a good extension for the lesson on hurricanes. After watching the short movies, the students will complete an art project. This activity comes from the unit Hurricanes and Tropical Storms. You will want to look at some of the connecting sites. The movies are a QuickTime application.

Source: Athena/Weather, WeatherEye is a public service of KGAN and is sponsored by Central Iowa Power Cooperative (CIPCO). The Athena project is a collaboration between SAIC, the Washington State Office of the Superintendent of Public Instruction, and the school districts of Seattle, Bellevue, Lake Washington, and Northshore.

http://weathereye.kgan.com/expert/hurricane/

About Athena:
(http://inspire.ospi.wednet.edu:8001/curric/weather/storms/index.html)
Athena engages students in observing phenomena using remote-sensed data to construct knowledge about the world. Data sets and instructional pieces are related to oceans, the atmosphere, Earth resources, and space/astronomy. Real-time data is used where possible. The material is intended for direct use by students with appropriate assistance from teachers. The goal of Athena is to enhance the K-12 science curriculum, and facilitate use of the powerful computational tools in classrooms networked to the Web.

Scientists and educators work together developing instructional material for K-12 science teaching based on data acquired via Internet. The materials include data sets with appropriate explanation, student activities, and teacher background information support for eighteen pilot sites in Seattle area classrooms. We support the pilot classes with onsite visits and e-mail, solicit feedback, and continue writing material in light of the classroom experience.

This project fills a need by making scientific data accessible to students in an understandable form. It does this by involving educators in planning and writing and piloting the material in classrooms. It provides a template for lessons and a model for collaboration between schools, business, and the government.

This site presents a senario of a town expecting a hurricane and connects to several other sites that have activities or weather related resources, such as the weather channel.

The Activity: The students will watch the movies of hurricane Andrew. They will be asked to watch carefully for any shapes that make you feel movement of the hurricane. What colors did you observe? Were the colors related to the shapes in any way? The student will draw a picture of a hurricane and color it. Where in your environment will you see these shapes? The students will add the shapes that look like movement into their journals. The students may be asked to make another art project that depicts the movement of the hurricane.

Correlation: The following learning and performance objectives correlate to this activity, and support Ohio proficiency test outcomes. You may use them to tailor this activity to your local curricular objectives and goals. Dayton Ohio Public Schools: This activity is suggested as an extension for Activities 21 and 22 on pages 52 to 55 in the *Rain or Shine...Here It Comes!* booklet for the fourth grade.

Ohio Proficiency Test in Science Learning Outcomes Correlation (4th Grade)

Strand II - Physical Science

11. Identify characteristics of a simple physical change.

Grade Level	Scientific Inquiry	Scientific Knowledge	Conditions for Learning Science	Applications for Learning Science	Performance Objectives
4	10, 11	2, 8, 11	13, 14		5
3	11	4, 7	10		2, 5

American Geological Institute Content Standards-Essential Questions 3-6: How does the weather change? How do we know when weather changes? How can we measure changing weather conditions? What can we learn from weather records?

National Science Education Standard- Grades K-4. Standard A: Use data to construct a reasonable explanation. Communicate investigations and explanations. Standard B: Properties of objects and materials. Position and motion of objects.

RETURN TO ACTIVITIES PAGE

Handle A Hurricane!

Students Become Mayors

Overview:

Students take the role of mayor of the city of Pensacola Beach, Florida. Hurricane Opal is developing/approaching in the Gulf of Mexico. The students must decide whether or not to order a forced evacuation of the city.

Students read actual news reports about the storm. They then read "memos" from city staff members, taking various positions on the evacuation. The students review basic information about hurricanes. Finally, students "announce" their evacuation decision by filling out a "press release."

Grade levels: 7-12
Prerequisites: None, but basic study of hurricanes would be helpful.
Time needed to complete: 60 to 90 minutes.

Lesson Objectives:

- Learn about hurricanes.
- Learn about the potential dangers to coastal towns.
- Use decision making skills.
- Use writing to explain a decision and answer questions about hurricanes.

Assignment:

- Decide whether or not to evacuate residents, based on facts about the hurricane and the town.
- Write an explanation of the decision, using the form included in the exercise.
NOTE: Teachers should print out this form in advance for the students. This form will be completed by hand and submitted to the teacher for grading.

Grading Suggestions/Answer Key:

- Based on responses to "press release" test sheet.
- Judged on using complete sentences and by any other writing standards that are appropriate for the students' grade level.

- Based on including appropriate facts to answer the questions.
- **Answer key is available by clicking here.**
  (Answer key section is password protected. If you have not registered, click here for information.)

Go to the "Handle the Hurricane" lesson.

Teachers' Lounge Main Page · Home Page

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News Summaries
Daily News Quiz
Word of the Day
Test Prep Question of the Day
Web Explorer
Science Q & A
Letters to the Editor
Ask a Reporter
Web Navigator

Parent CONNECTIONS

Conversation Starters
Family Movie Guide
Vacation Donation Plan
Discussion Topics

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DAILY LessonPlan

Developed in Partnership with the Bank Street College of Education in NYC

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Related Article
The Right Moves, When Heat Can Kill
The Associated Press

(Go to Article.)

Tuesday, July 13, 1999

The Heat Is On!

Creating Weather Emergency Guides in the Science Classroom

Author(s)
Alison Zimbalist, The New York Times Learning Network

Grades: 6-8, 9-12
Subjects: Health, Science
Interdisciplinary Connections

Overview of Lesson Plan: In this lesson, students research various types of severe weather conditions common to their geographic location and create weather emergency guides. Students work in groups to develop guides for extreme weather conditions such as heat waves, tornadoes, floods, and storms, focusing on understanding the formation of these types of weather conditions, forecast and surveillance methods, preparation, and safety procedures in the event of an emergency.
Review the Academic Content Standards related to this lesson.

Suggested Time Allowance: 45 minutes

Objectives:
Students will:
1. Recall situations in which they were caught in severe weather, and analyze how they felt during and after this situation.
2. Examine heat-related illnesses, focusing on their symptoms and treatments, by reading and discussing "The Right Moves, When Heat Can Kill."
3. Explore various extreme weather conditions common to their geographic location, researching the formation of these types of weather conditions, forecast and surveillance methods, preparation, and safety procedures in the event of an emergency.
4. Develop weather emergency guides for the types of extreme weather studied, to be distributed throughout the school or community in the appropriate seasons.

Resources / Materials:
-student journals
-pens/pencils
-paper
-classroom blackboard
-copies of "The Right Moves, When Heat Can Kill" (one per student)
-weather resources (science textbooks, encyclopedias, weather books, Internet access)

Activities / Procedures:
1. WARM-UP/ DO-NOW: Students respond to the following in their journals (written on the board prior to class): Think about a time when you were trapped in terrible weather (a blizzard, a heat wave, a thunderstorm, a tornado, a flood, a hurricane, or any other type of storm). Recall how you felt during and after this situation. How does the uncontrollable aspect of these situations affect how people feel when they are involved in them? Students should be encouraged to share their responses. Students then discuss what they have heard from news sources lately about heat waves and the destruction that they cause.

2. Read and discuss "The Right Moves, When Heat Can Kill," focusing on the following questions:
a. How are high temperatures dangerous to the human body?
b. What causes sunburn, and how can one treat it?
c. What causes heat cramps, and how can they be treated?
d. How can one tell the difference between heat exhaustion and heatstroke or sunstroke? In what ways are their treatments very different, and why?
e. What do you think people can do to prevent succumbing to these types of heat-related illnesses?
f. What other weather conditions can bring about health problems?

3. As a class, list on the board the different extreme weather conditions that occur in your area (heat waves, tornadoes, flash floods, winter storms, hurricanes, severe thunderstorms, floods, etc.). Then, divide students into as many small groups as there are extreme weather conditions listed on the board. Explain to students that they will be researching their weather conditions and then creating weather emergency guides. Using all available classroom resources, students should answer the following (listed on the board for easier student reference):
--What is the "definition" of this type of extreme weather?
--How does this type of weather form?
--What geographical locations are prone to this type of weather, and why?
--What methods are used to forecast this type of weather, and how do they work?
--What surveillance methods are used to track this type of weather, and how do they work?
--How can one prepare for this type of weather emergency?
--What should one do in the event of this weather emergency?

4. WRAP-UP/HOMEWORK: After groups have finished their research, each group develops a weather emergency guide for the extreme weather studied. Guides should be no longer than four pieces of paper (two pages front-and-back) so that they can be easily duplicated and distributed. Guides must answer all research questions, should provide interesting illustrations (such as pictures and charts), and should be easy to understand. Guides can then be reproduced on colored paper and distributed throughout the school or community in the appropriate seasons of the year when this weather is likely to occur.

Further Questions for Discussion:
--What is a heat wave?
--What weather conditions cause extreme heat?
--How do people often put themselves in danger in extreme heat conditions?
--What elements of a city's infrastructure are affected in the event of a heat wave?
--How can one prepare for a heat wave?
--What severe weather conditions occur in your community every year, and how do people usually prepare for these conditions?

Evaluation / Assessment:
Students will be evaluated based on written journal response, participation in class discussions, group research on a type of severe weather, and well-designed and thorough weather emergency guide on the severe weather researched.

Vocabulary:
taxing, symptoms, dissipate, excess, humid, sterile, spasms, clammy, unconsciousness, summon, fatal

Extension Activities:
1. Research when warnings are officially issued for different extreme weather conditions. What is the difference between a "watch" and a "warning," and what specific weather conditions are classified in each category?

2. Create a handout about water and energy conservation tips that are effective in periods of extreme heat.

3. Design an Internet scavenger hunt about heat waves, finding different Web sites that relate to this weather condition and jotting down one question that can be answered by each Web site you find. Then, challenge a family member or friend to answer your questions about heat waves by using your Internet scavenger hunt.

4. Create a "How It Works" poster or display that explains how the human body regulates its temperature. You might want to create similar displays for different animals.

5. Invite a meteorologist from a local television station to speak to your class about weather tracking and what one should do in various emergency weather situations.

6. Research what supplies you should have on hand in the event of severe weather situations and create a supply kit for your family.

7. Develop an emergency guide for your family, including maps to help your family escape or protect themselves in the event of different emergencies (such as flood, tornado, hurricane, and fire). Be sure that you review this information with all members of your family.

8. Conduct a heat safety inventory of your home, itemizing products and items that you own and need to be safe in conditions of extreme heat.

Interdisciplinary Connections:
Geography/Mathematics- Map and graph weather patterns (temperature, precipitation, fronts, etc.) over the next month or the rest of the season for your state, region or country.

Mathematics- Track statistical data on past and present heat waves (area of land affected, total dollar amount of damages, temperature, statistics about victims, location comparisons, etc.) on charts or graphs.

Social Studies
-Investigate the different government services that warn people about impending weather systems and that offer aid to victims of weather disasters.
-Explore how various elements of a city's infrastructure (commerce/trade, food supply, health care, communication/roads, shelter, power supply) are affected by extreme weather conditions (such as heat waves) or natural disasters.

Teaching with The Times- Over the course of one or two weeks, collect and create a collage of headlines, graphs, maps and photos from The New York Times that relate to extreme weather conditions currently happening around the world. Then, analyze how and why these weather conditions are affecting the "victims" of them differently.

Other Information on the Web
The National Weather Service (http://www.nws.noaa.gov/) provides current official weather warnings, observations, and forecasts.

American Red Cross: Heat Waves (http://www.redcross.org/disaster/safety/heat.html) discusses what a heat wave is, what to do to protect yourself, and how to recognize and treat heat-related health emergencies.

Weather Channel Encyclopedia: Heat Wave (http://www.weather.com/breaking_weather/encyclopedia/heat/) teaches about extreme heat safety, heat climatology, forecasting heat, historical heat waves, the UV index, and droughts.

Academic Content Standards:
McREL This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8

Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows factors that can impact the Earth's climate; Knows the processes involved in the water cycle
Health Standard 2- Knows environmental and external factors that affect individual and community health. Benchmarks: Knows cultural beliefs, socioeconomic considerations, and other environmental factors within a community that influence the health of its members; Understands how various messages from the media, technology, and other sources impact health practices
Health Standard 7- Knows how to maintain and promote personal health. Benchmarks: Knows personal health strengths and risks; Knows how positive health practices and appropriate health care can help to reduce health risks; Knows strategies and skills that are used to attain personal health goals; Understands how changing information, abilities, priorities, and responsibilities influence personal health goals
Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmark: Knows the consequences of a specific physical process operating on Earth's surface
Benchmarks: Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Knows the ways in which human systems develop in response to conditions in the physical environment; Knows how the physical environment affects life in different regions; Knows the ways people take aspects of the environment into account when deciding on locations for human activities; Knows the effects of natural hazards on human systems in different regions of the United States and the world; Knows the ways in which humans prepare for natural hazards
Language Arts Standard 4- Gathers and uses information for research purposes. Benchmarks: Uses a variety of resource materials to gather information for research topics; Determines the appropriateness of an information source for a research topic

Grades 9-12
Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows that weather and climate involve the transfer of energy in and out of the atmosphere; Knows how winds and ocean currents are produced on the Earth's surface
Health Standard 2- Knows environmental and external factors that affect individual and community health. Benchmarks: Understands how the environment influences the health of the community; Understands how the prevention and control of health problems are influenced by research and medical advances
Health Standard 7- Knows how to maintain and promote personal health. Benchmarks: Knows how personal behaviors relate to health and well-being and how these behaviors can be modified if necessary to promote achievement of health goals throughout life; Understands the short- and long-term consequences of safe, risky, and harmful behaviors; Understands how personal health needs change during the life cycle
Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmarks: Understands the distribution of different types of climate that are produced by such processes as air-mass circulation, temperature, and moisture; Understands the effects of different physical cycles on the physical environment of Earth; Understands how physical systems are dynamic and interactive; Understands how physical processes affect different regions of the United States and the world
Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Understands how people who live in naturally hazardous regions adapt to their environments; Knows factors that affect people's attitudes, perceptions, and responses toward natural hazards
Language Arts Standard 4- Gathers and uses information for research purposes. Benchmarks: Uses a variety of news sources to gather information for research topics; Determines the validity and reliability of primary and secondary source information and usesinformation accordingly in reporting on a research topic

Send feedback on this lesson.

Browse or search the lesson plan archive.

>Search classified
>Find a job
>Buy a car
>Find real estate
>Place a classified ad
>Shopping
>Grocery coupons

HURRICANE

Hurricane Home

TRACKING THE STORM
- Maps and data
- Online tracking map
- Printable tracking map
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STORM SURVIVAL
- Before the storm
- During the storm
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- Choosing shutters

LEARN MORE
- 500 years of history
- Hurricane Andrew
- S. Florida's 8 worst hurricanes
- Hurricane names
- Hurricane science

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August 29, 2004

HURRICANE HEADQUARTERS

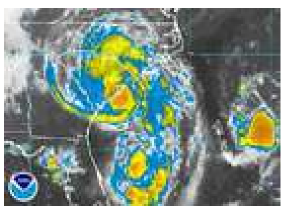
Keep your eye on Hurricane Frances

A well-organized Hurricane Frances was aiming in the general direction of South Florida on Sunday, threatening to grow into a dreaded Category 5 system. Hurricane officials are appealing to residents to make preparations now.

125,000 lose power as Gaston slops ashore in South Carolina (6:13 PM)

Charley's destruction shows need for safe rooms (12:41 PM)

125,000 lose power as Gaston slops ashore in South Carolina

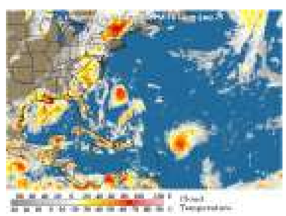


Tropical Storm Gaston sloshed ashore in South Carolina Sunday with near hurricane-force winds, spinning sheets of rain that flooded roads as the storm knocked out power to thousands of people.

Gaston's landfall

Keep your eye on Hurricane Frances (12:02 PM)

Latest hurricane updates



- Official NHC outlook
- Tropical data

Maps:
- Atlantic
- Gulf of Mexico
- Caribbean

Close call: Tampa radar failed just before Charley hit

WASHINGTON -- As Hurricane Charley bore down on Florida this month, the principal radar covering the landfall area went down due to mechanical failure -- and wasn't restored until 14 hours before the storm smashed into the state, according to documents and officials.

Keep your eye on Hurricane Frances (12:02 PM)

PHOTOS: Hurricane Charley's aftermath

Signs of stress showing as Charley survivors settle in

PORT CHARLOTTE -- In the days after Hurricane Charley rifled their homes and businesses, a polite shock settled over this ravaged town. Neighbors

ACTIVE STORMS

Hurricane Frances
Updated: 5 p.m. EDT
Location: 18.8 N, 55.6 W
Moving: W at 9 mph
Wind: 135 mph, gusts to 160 mph
Pressure: 949 mb (28.01 in)

Tropical Storm Gaston
Updated: 5 p.m. EDT
Location: 33.9 N, 79.6 W
Moving: N at 8 mph
Wind: 40 mph, gusts to 50 mph
Pressure: 1000 mb (29.52 in)

Tropical Storm Hermine
Updated: 5 p.m. EDT
Location: 32.4 N, 71.0 W
Moving: NW at 10 mph
Wind: 40 mph, gusts to 50 mph
Pressure: 1008 mb (29.76 in)

HURRICANE CHARLEY: The aftermath in photos.

E-MAIL UPDATES

Stay alert. **Sign up to get hurricane updates** delivered by e-mail.

COLUMNISTS

Michael Mayo
News Columnist

Rethinking recent acts, events

Howard Goodman
Palm Beach columnist

Goodman: A dad who gave his full attention - and his love

Rick Stone
Square One

Zip code tells a story

Michael Turnbell
TRANSPORTATION COLUMNIST

Eyes will keep 24/7 watch on I-95

Vanessa Bauza
News Columnist

Buddy Nevins
Political Columnist

Anthony Man
Political columnist

Ken Kaye
Aviation Columnist

Nightlife & Bars
Florida Getaways
Celebrity News
Horoscopes
Attractions & outdoors
Visitor's Guide

FEATURES SECTIONS
Lifestyle
Food
Home & Garden
Travel
Books

HEALTH

COMMUNITY

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CORRECTIONS

OTHER SERVICES
Archives
Customer service
News by e-mail

checked on neighbors. Motorists took turns at darkened lights, dodging downed power poles and tree boughs.

Wary, waiting

Victims of Hurricane Charley file for unemployment as services slowly resume (5:53 PM)

Complacency, our biggest enemy

Proposed multimillion-dollar interactive center in Deerfield to portray hurricane effects

Be prepared when hurricanes or other emergencies strike

Forecasters use new tool to predict rapid storm intensification

The good side of hurricanes -- from 'spiritual rebirth' to restoring habitats

Masters of disasters: Red Cross volunteers step in to save day

Florida's forgotten storm: The Hurricane of 1928

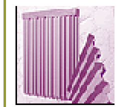
10 lessons for a category 5 hurricane

Finding shelter for your family

Make plans now to protect your family

Shutters are first line of defense

SHUTTER GUIDE



From plywood to hurricane glass, learn about the **pros and cons** of the different shutter systems. Then use our **online calculator** to estimate your cost.

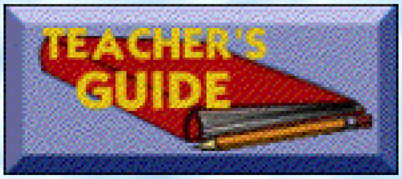
WORTH A LOOK

It's been a decade since **Hurricane Andrew hit South Florida**. Look back with eyewitness accounts, "then and now" photos and original articles from 1992.

2004 STORM NAMES

Alex, Bonnie, Charley, Danielle, Earl, Frances, Gaston, Hermine, Ivan, Jeanne, Karl, Lisa, Matthew, Nicole, Otto, Paula, Richard, Shary, Tomas, Virginie, Walter

[Quilt | Inside a Hurricane | Survivors | Weather Instruments | Killer Storms]



Welcome to the storm center. **CLICK** on any title above to find out more about hurricanes. Or see the current weather data at the Miami Museum of Science. For current hurricane data, consult our Hurricane Hotlist.

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Museum Menu

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Science Learning Network / Inquiry Resources

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University of Illinois

WW2010
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- about ww2010
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Online Guides
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Meteorology
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- movement
- public awareness
- public action
- damage
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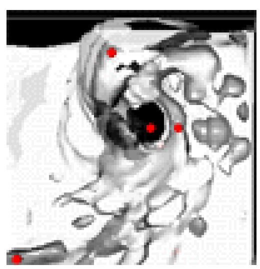
- el nino

User Interface
- graphics
- text

Graphic by: Dan Bramer



Fly through a 3-D Hurricane!
added (1/08/1999)

Requires a VRML player/plugin. See bottom of page for a recommended one.

Interact with Atlantic hurricanes from 1950-2003!!

Hurricanes are cyclones that develop over the warm tropical oceans and have sustained winds in excess of 64 knots (74 miles/hour). These storms are capable of producing dangerous winds, torrential rains and flooding, all of which may result in tremendous property damage and loss of life in coastal populations. One memorable storm was Hurricane Andrew (pictured above), which was responsible for at least 50 deaths and more than $30 billion in property damage. The purpose of this module is to introduce hurricanes and their associated features, to show where hurricanes develop, and to explain the atmospheric conditions necessary for hurricane development. The Hurricane module has been organized into the following sections:

Sections

Last Update: 09/16/99

The navigation menu (left) for this module is called "Hurricanes" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Recommended VRML plugin:

Land Breezes

Terms for using data resources. CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

Growth Processes

Hurricanes

E-mail Search Home

» The 15 Biggest Hurricanes From 1900-2000

» The History Of Hurricanes

» Why Can't We Stop Hurricanes?

» Hurricane IQ Quiz

» How to Track a Hurricane

» Hurricane Classification

» Past Major Hurricanes

» Hurricane Names

» Starting Points for Hurricanes

» Hurricane Cartoons

» Hurricane Disaster Math

» Disaster Intensity Scales

» Hurricane House Game

» Hurricane Videos

» Water, Wind and Earth Game

» Hurricane Hunters

» Mary Ann and Hurricane Camille

Hurricanes are severe tropical storms that form in the southern Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and in the eastern Pacific Ocean. Hurricanes gather heat and energy through contact with warm ocean waters. Evaporation from the seawater increases their power.

Hurricanes rotate in a counter-clockwise direction around an "eye." Hurricanes have winds at least 74 miles per hour. When they come onto land, the heavy rain, strong winds and heavy waves can damage buildings, trees and cars. The heavy waves are called a storm surge. Storm surges are very dangerous and a major reason why you MUST stay away from the ocean during a hurricane warning or hurricane.

FEMA for Kids

Federal Emergency Management Agency

LESSON PLANNING ARTICLE

Hurricanes Spark a Storm of Classroom Activity!

Hurricane season is here! Use some of these activities and Internet connections to engage students of all ages in a study of these powerful and frightening storms.

Hurricane season has begun! Last week, two of the seasons biggest hurricanes hit. Fabian pounded Bermuda and Henri paid an unwelcome visit to the Florida Gulf Coast.

So what will the balance of the hurricane season be like? The outlook is not good. Colorado State University's hurricane expert, William Gray, said in his forecast that this year he expects above-average hurricane activity, including 14 named storms.

"It appears that we have left the period of lessened hurricane activity and it is possible we could be seeing a basic change in the long-term global circulation patterns," Gray said. "This change could result in increased hurricane activity, perhaps somewhat similar to the very active period of the mid-1940s to the late 1960s."

Officially, the Atlantic "hurricane season" lasts from June 1 to November 30. In an "average" hurricane season, meteorologists track 9.3 tropical storms, 5.8 hurricanes, and 2.1 major hurricanes.

HURRICANE CLASSROOM ACTIVITIES

You and your students can follow this year's hurricane activity. On the Internet, you'll be deluged with hurricane-related sites; I've highlighted a few below in the Tracking Hurricanes on the Internet section. Immediately following is a handful of activities that you might include in a hurricane lesson plan or that you might use to supplement a current-events discussion of "hurricane season."

ABC Order. Each year, hurricane names are assigned in alphabetical order. The list of names is recycled every six years. The names of 2003's North Atlantic hurricanes are listed below out of sequence. Invite students to put the list in alphabetical order. (For younger students, you might narrow the list to the first ten (A-J) named hurricanes of the season.)
Danny, Isabel, Fabian, Sam, Wanda, Bill, Mindy, Victor, Odette, Erika, Henri, Ana, Rose, Peter, Kate, Grace, Teresa, Juan, Nicholas, Claudette, Larry. (Note: No hurricane names are assigned for the letters Q, U, X, Y, and Z.)

Click here for a complete list of Eastern Pacific hurricanes.

Read aloud. *Hurricanes: Earth's Mightiest Storms by Patricia Lauber (Scholastic)*. Not just another book about "big weather," this is an amazing work that uses narrative very effectively in weaving the story of these powerful storms. Clearly written and relevant text is combined with impressive photographs and informative maps and illustrations that further enhance this excellent work. (Recommendation source: *Science and Children*, March 1997.)

Hands-On Science. Static electricity is stored in rain clouds. When a cloud is so full of static electricity that there's no room for any more, a spark might leap from the cloud. That spark is called "lightning"! Your students can demonstrate the effects of static electricity. Invite them to try the following simple experiment. (Note: This experiment works best when the weather is dry.)

Social Sciences
Technology

Specialties
Counseling
Early Childhood
Higher Ed
Preservice Ed
Special Ed
Vocational Ed

Reference Center
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"Best Of" Series
Careers
Contests/ Competitions
Ed Standards
Grants Center
Holidays
Message Boards
Newsletters
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World Resources
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Help

1. Tear up a sheet of paper into tiny little pieces.
2. Invite students to use a comb to comb their hair. Or rub the comb on a piece of wool or fur.
3. Then hold the comb over the tiny paper pieces.
4. What happens? Why does it happen?

Research. Invite students to learn more about hurricanes. Pose the following questions and see who is the first to come up with the correct answers to all the questions. (You might use this activity as a cooperative group activity.)

1. What's the difference between a hurricane, a cyclone, and a typhoon? *(They are all the same kind of storm but hurricanes develop in the Atlantic Ocean, cyclones develop in the Indian Ocean, and typhoons develop in the China Sea.)*
2. What is the origin of the word "hurricane"? *(The word "hurricane" came from the Mayan culture of Central America. The Mayans called their storm god "Hunraken.")*

Critical thinking:

1. What do you notice about the names of hurricanes? *(Use the list that students created in the ABC Order activity above.)*
2. What special sequence do you see in those names? *(The names alternate between male and female names; in 2003 the list starts off with a female name, so in 2004 the list will begin with a male name.)*

Science: The Water Cycle. Discuss and draw a simple illustration on a board or chart to demonstrate to students the steps of the water cycle: (1.) Energy from the sun changes water to water vapor. (2.) Water vapor rises. It cools and condenses to form clouds. (3.) Winds blow the clouds over land. (4.) Clouds meet cool air, and rain or snow falls to the ground. (5.) Most of the water returns to large lakes and oceans. Next, invite students to demonstrate the water cycle:

1. Fill a large, glass bottle or jar half full of water.
2. Cover the jar with plastic wrap and secure the plastic wrap in place with an elastic.
3. Place the jar in a sunny window.
4. Observe for a few hours. What happens? Why did it happen? *(Water drops form on the underside of the plastic wrap. Energy from the sun turned the water into water vapor (evaporation) which caused water drops to form (condensation) on the plastic wrap.)*

Invite students to compare what happened in the jar to the way the water cycle works? Talk about ways they might speed up the process of evaporation and condensation? How would that compare to a hurricane?

Graphing. Invite students to create bar graphs using weather data.*
For younger students: More hurricanes strike in September than in any other month. Make a bar graph to show how many hurricanes have struck each month.

June	12 hurricanes
July	16 hurricanes
August	40 hurricanes
September	61 hurricanes
October	23 hurricanes
November	6 hurricanes

(Data shows totals for 1900-94.)

For older students: The number of deaths caused by hurricanes has dropped dramatically since the turn of the century. Invite students to use the data below *to draw a bar graph that will show this trend.*

1900-1909	8,100 deaths
1910-1919	1,050 deaths
1920-1929	2,130 deaths
1930-1939	1,050 deaths
1940-1949	220 deaths
1950-1959	750 deaths
1960-1969	570 deaths
1970-1979	226 deaths
1980-1989	161 deaths

* Data source: USA Today.

Art. Invite students to create a cartoon to illustrate the following joke:

Why don't weather forecasters tell each other jokes?
(Answer: They don't want to laugh up a storm!)

Geography. Follow the course the next hurricane of the season takes. Invite students to track the hurricane for themselves on their own copies of a U.S. map. They should label cities/towns that are along the hurricane's path and the date and time when the hurricane hit those locations.

Article by Gary Hopkins
Education World®Editor-in-Chief

Related Resources

TRACKING HURRICANES ON THE INTERNET

You might appoint a "hurricane tracking team" or you might assign individual students or small groups to track some of the following sites for hurricane information.

- Children, Stress, and Natural Disasters-A Guide for Teachers This site includes classroom activities for helping children prepare for, survive, and deal with a natural disaster such as a hurricane. (Click here for Education World's detailed Site Review of this site.)
- Hurricane: Storm Science Learn how storms happen, all about tracking storms, how to make a weather station, and more on this site from (appropriately) the Miami Museum of Science.
- Natural Disasters Around the World Another feature of the site created for the Miami Museum of Science.
- CNN's Weather Story Page Check out CNN's weather page for the latest forecasts, weather maps, allergy report, and news from the storm center.
- USA Today's Weather Click on the yellow WEATHER button in the masthead of USA Today's main page for today's temperature map, top weather news, and lots more.
- The Weather Channel's weather.com This site includes weather headlines and a search engine that allows you to check weather for a particular city or state. Maps, safety tips, and much more.
- Storm 2003 Detailed maps (Storm97 Tracker) show the current position of a hurricane. Excellent, clear maps will help show precise location, wind speeds, and more.
- Kids as Global Scientists Join with students around the world as they engage in a real-time, inquiry-based weather curriculum in 1997. Or pull up the Fall '96 curriculum with activities for all ages.
- National Hurricane Center Tropical Prediction Center A good place to go

for current advisories, reviews of 1995 and 1996 hurricanes, and historical storm data (e.g., deadliest, most expensive, most intense storms).

Originally published 08/01/1997
Article updated 09/05/2003

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Field Trip List

Hurricane Field Trip

Trailhead | Teacher's Resources | Start Field Trip

A hurricane is a type of tropical cyclone that sustains winds of 74 miles per hour and greater. Hurricanes occur in the tropical regions of the world in 7 distinct basins, and are called **Hurricanes** in the Carribean, Atlantic, Gulf of Mexico, and eastern Pacific, **Typhoons** in the western Pacific, and **Cyclones** in the Indian Ocean. A hurricane "watch" is issued when the threat of storm conditions is expected between 24-36 hours. A "warning" is issued when the storm is expected within 24 hours or less.

Objectives

- Students will learn what a hurricane is, and how and where they are formed.
- Students will learn how to prepare for a hurricane and what to do in the event of a storm.
- Students will be taken to some of the best hurricane resources available on the Web where they can research and retrieve all kinds of storm data including historical storms, careers, tracking instruments, current weather maps, and much more.

See our Awards

Concepts

1. What conditions are necessary to create a hurricane?
2. Where do hurricanes occur?
3. When is hurricane season?
4. What is the difference between a tropical cyclone and a hurricane?
5. How is the strength of a hurricane measured?
6. Where do hurricanes get their names?

Terms To Learn

climatology
dropsonde
eye
eyewall
millibar
Saffir-Simpson Scale
storm surge
tropical cyclone
tropical depression
warning
watch

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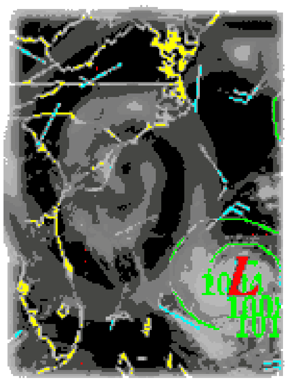
Send mail to info@tramline.com with questions or comments about this Web site.

LESSON PLANNING ARTICLE

Hurricane Watch!

To your students, September probably means new friends, new books, and new and exciting adventures. But to meteorologists, September signifies an adventure of another kind. It's the peak month of the Atlantic hurricane season. This week, Education World brings the two together, providing activities designed to help your students understand this powerful force of nature.



Most residents of the United States will never experience a hurricane first hand. But all will hear, at some time in their lives, news reports about the destruction caused by one of these violent storms. Just what are hurricanes? How do they form? Who do they affect? What damage do they cause? The information and activities below will help you answer those questions, as well as provide some exciting additions to your curriculum.

WHAT'S IN A NAME?

Hurricane is, in fact, just one name for the kind of storm scientists refer to as a strong tropical cyclone. When the same kind of storm occurs in the eastern Pacific Ocean, it's called a *typhoon*. In the southwest Pacific Ocean and the Indian Ocean, the storms are called *cyclones*.

Tropical cyclones develop when thunderstorms form over ocean water that has reached a temperature of about 80 degrees Fahrenheit. The conditions required for tropical cyclones, or Hurricanes, to develop occur most often in late summer and early fall. An average of nine named tropical storms develop each year in the Atlantic basin, six of which become hurricanes. Of those, two are likely to become intense hurricanes and cause extensive damage.

The following activities will help your students understand hurricanes and appreciate their power and consequences. The activities are grouped under two headings, Hurricane Activities for All Students and Hurricane Activities for Upper Elementary Students and Above.

HURRICANE ACTIVITIES FOR ALL STUDENTS

Language arts -- alphabetical order. Provide students with a scrambled list of World-Wide Tropical Cyclone Names from this year's hurricane season and have them put the names in alphabetical order. Which letters do not have an associated hurricane name? You might want to explain that tropical storm names are assigned by the World Meteorological Organization.

More language arts -- alphabetical order. Ask students to work in small groups to create their own alphabetical list of names they'd attach to hurricanes -- if they were responsible for naming them!

Science -- make a weather station. Encourage younger students to visit Making a Weather Station and help them follow the directions to create a classroom weather station.

Geography -- track a hurricane. Provide students with a Tracking Map and invite them to track the path of a current storm or a storm from a previous year.

Math -- solve word problems. Encourage students to visit Disaster Math and solve the problems. For very young students, use these word problems as a guide to creating your own.

Hands-on science -- making lightning. Lightning is caused by static electricity stored in rain clouds. When the clouds have too much stored static electricity, a spark results --- lightning! Students can demo how lightning is formed by tearing a small square of paper into tiny, confetti-like pieces. Mext, take a comb and hold it near the confetti. Nothing happens. Then they can briskly run the comb through their hair. Hold the "charged" comb over the confetti. What happens? You can't see the static electricity you've created but you can see its results. In what other ways can you create static electricity?

Math -- make a graph. Hurricanes cause millions of dollars in damages each year. Invite students to create a bar or picture graph to show the costs of hurricane damage over the decades. Data is provided below. (Data source: *USA Today*)

1920s	$2 billion
1930s	$4 billion
1940s	$4 billion
1950s	$11 billion
1960s	$17 billion
1970s	$17 billion
1980s	$15 billion

Home connection -- health and safety. Print copies of the Hurricane Kit Checklist and send a copy home with each student. Have students include a letter explaining specific concerns they have regarding storms and encourage them to discuss both their concerns and the checklists with their families.

Hands-on science -- demonstrate the water cycle. Use this experiment to demonstrate the water cycle. (The sun changes water to water vapor, which rises, cools, and condenses to form clouds. Then cool air meets the clouds, creating rain, sleet, or snow.) Have students fill jars half-full of water. Cover the jar openings with plastic wrap and use rubber bands to seal. Place the jars on a sunny windowsill. Ask: What happened? Why? What signs did you see of condensation? evaporation? How does this experiment demonstrate the water cycle?

Art/Language arts -- create a class joke book. Invite each student to create a humorous picture to illustrate this joke: Why won't weather forecasters tell each other jokes?
They don't want to laugh up a storm! Choose the best illustration of this joke to be the cover of a class joke book. Then invite each student to choose a favorite riddle or joke to illustrate and to add to the class joke book.

Games -- challenge a computer. Invite students to explore probability as they play the Water, Wind, and Earth game against the computer.

HURRICANE ACTIVITIES FOR UPPER ELEMENTARY STUDENTS AND ABOVE

Geography -- read a world map. Encourage students to visit Tropical Storm Tracks and explore the areas listed to find current tropical storms. On a world map, help students locate the seven areas where tropical storms occur and ask them to identify countries that might be affected by storms in each of those areas. Students might also determine, for each area, whether storms there are called typhoons, cyclones, or hurricanes.

Science -- create a chart. Encourage students to go to Davis Weather Instruments' Virtual Weather Station and explore the company's VantagePro product. Help students create a chart of the data provided for several different weather situations. Then ask them to hypothesize about the correlation between wind-chill temperature and wind speed, humidity level and rainfall amounts, and so on. Have students record weather information given for their area for a week or two and then test their hypotheses.

Social studies -- write a press release. Encourage older students to complete the Handle a Hurricane lesson plan, at which they will learn about hurricanes, explore social factors, and decide whether to evacuate Pensacola Beach, Florida, as a hurricane approaches.

Writing -- create a newspaper. Arrange students into groups and provide each group with a list of Retiring Names of the Worst Hurricanes. Ask each group to choose from the list a hurricane that affected the United States, research the hurricane, and then create a newspaper about it. Encourage students to name their newspapers appropriately based on the hurricane's path, to accurately represent costs according to the actual year in which the hurricane occurred, and to include graphics, advertisements, and cartoons that reflect the concerns of area residents.

Art -- create a diorama. Arrange students into five groups and assign each group a hurricane category, from 1 to 5. Then have students create a hurricane of the assigned category. You might want to explain that a Category 2 hurricane has 10 times the destructive power of a Category 1 hurricane, a Category 3 hurricane has 50 times the destructive power of a Category 1 hurricane, a Category 4 has 100 times the power, and a Category 5 has 250 times the destructive power. Then ask each group to create a diorama showing the damage to a building that might result from their hurricane.

Geography -- learning latitude and longitude. Introduce the Interactive Tracking Map. Then have students explore another Interactive Tracking Map and click **Quick Plot** to practice plotting their own coordinates. Then provide students with a map of the United States or the world, give them several sets of coordinates, and ask them to find the locations on the map.

Science -- take a quiz. Encourage students to take the quizzes at Test Your Hurricane IQ, Hurricane Quiz, or Hurricane Quiz. For ESL students, see the ESL Hurricane Quiz.

Math -- calculate inflation. Ask students to go to Stormfax Weather Services, click **Hurricanes**, then **United States Hurricane Statistics** (1900-1997), scroll down to U.S. Hurricane Statistics: 1990-1997, and explore both **Top 25 Costliest /actual $$** and **Top 25 Costliest /adjusted $$**. Then have students calculate the rate of inflation between each hurricane and 1997.

Related Sites

ADDITIONAL HURRICANE RESOURCES ON THE INTERNET

- Science Friday Kids' Connection: Hurricane! Middle school science teachers will find lots of great material here for teaching about hurricanes.
- Stormfax Weather Services Provides an extensive array of weather information for the United States and the world, including a daily weather map and satellite images.
- The National Hurricane Center Everything you ever wanted to know about hurricanes, typhoons, and tropical cyclones.
- The National Weather Service Interactive Weather Information Network Provides weather and tracking information for many different kinds of storms, including hurricanes.
- The USA Today Hurricane Index A good source for clearly written

hurricane information and news.

- Hurricanes A report on hurricanes by eighth grade students.
- South Florida Sun Sentinel Hurricane Information Includes a timeline of fascinating hurricane history, a quiz, an interactive map, and more.
- Hurricanes From the University of Illinois, this site provides lots of hurricane information accompanied by clear explanations and many definitions.
- The Image Catalog Satellite pictures of hurricanes from NASA and The Movie Catalog movie clips.
- Severe Weather -- Hurricanes Provides an activity your students can use to track and analyze a hurricane.
- FEMA For Kids Provides storm drawings, games, a 1998 hurricane forecast, and hurricane videos.
- Hurricanes: How They Work and What They Do A variety of basic information about hurricanes.
- Hurricanes Links from Clemson University to sites containing hurricane information, safety tips, and activities.
- Hurricane: Storm Science from the Miami Museum of Science A great deal of information for younger students, including directions for making weather instruments, a healing quilt for storm survivors, letters from storm survivors, and statements from a family that lived through Hurricane Andrew.

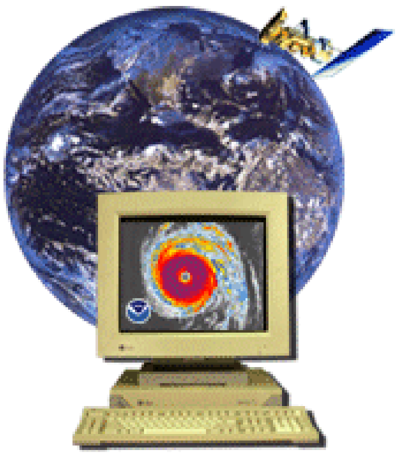
Article by Linda Starr
Education World®

Related Articles from Education World

- Hurricanes Spark a Storm of Classroom Activity!
- Forecasters Fear El Niño Year
- Kids "Tune In" to Weather Curriculum

Originally published 09/07/1998
Links updated 09/11/2003

Get/View Online Satellite Data



- Historical GOES Browse Server
- Satellite Active Archive (Lev 1b POES/DMSP DATA)
- Images/Movies of Hurricanes and Special Events
- SSM/I Global Gridded Files from FTP server
- SSM/I Monthly Image Products
- Satellite's Eye Art Galleries (discussions and images)

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http://www.ncdc.noaa.gov/ol/satellite/satellitedata.html
Last updated 01 April 2004 by ncdc.webmaster@noaa.gov
Please see the NCDC Contact Page if you have questions or comments.

Top News of the Day

- **An Active 2004 Atlantic Hurricane Season Likely**
  Press Release - 2004 Atlantic Hurricane Outlook (August Update)
- **More NHC/TPC news...**

National Hurricane Center

(Our Mission and Vision)

Active Tropical Cyclones
Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and the Eastern Pacific out to 140°W
Remember to Refresh or Reload this page for the latest information
Need help with getting the latest information?
Page last modified Sunday, 29 Aug 2004 23:03:13 GMT

Atlantic & Caribbean — **NWS Hurricane Local Statements**

HURRICANE FRANCES

Public Advisory #20 5 PM AST	Aviso Público* #20 5 PM AST	Forecast/ Advisory #20 2100Z	Discussion #20 5 PM EDT	Probabilities #20 5 PM AST	Maps and Charts	Archive

TROPICAL STORM GASTON

Public Advisory #9 5 PM EDT	Aviso Público* #9 5 PM EDT	Forecast/ Advisory #9 2100Z	Discussion #9 5 PM EDT	Probabilities #9 5 PM EDT	Maps and Charts	Archive

Breakpoints

Hurricane History
TPC Archives
Climatology
Deadliest
1492-1996 (Atlan)
1900-2000 (USA)
Most Expensive
Most Intense
US Strikes by Decade
US Strikes by State

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TPC Personnel
NOAA Locator
Visitor Information
NHC Library
Joint Hurricane Testbed
WX4NHC Amateur Radio Station
TPC Anonymous FTP Server

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Webmaster

TROPICAL STORM HERMINE

Public Advisory #1 5 PM AST	Forecast/ Advisory #1 2100Z	Discussion #1 5 PM EDT	Probabilities #1 5 PM AST	Maps and Charts	Archive

Eastern Pacific

TROPICAL STORM GEORGETTE

Forecast/ Advisory #14 2100Z	Discussion #14 2 PM PDT	Maps and Charts	Archive

Hurricane Preparedness
Learn about the hazards of hurricanes and what you can do to help protect yourself, your family, and your property.

Worldwide Tropical Cyclone Centers
- **Central Pacific Hurricane Center (140°W to 180°)**
- **Joint Typhoon Warning Center (Western Pacific and Indian Ocean)**
- **Canadian Hurricane Center**
- **Worldwide Tropical Cyclone Centers**

Tropical Weather Outlooks and Full-Basin Maps
- **Atlantic (en Español*)**
- **Eastern Pacific**

***Spanish translations courtesy of the NWS San Juan Weather Forecast Office**

Tropical Weather Discussions, Marine Forecasts, and SST Analyses
- **Tropical Weather Discussions**
- **Marine Forecasts (and all TAFB products)**
- **Sea Surface Temperature Analyses**

News and Information

- **2004 Experimental East Pacific Hurricane Outlook Released**
- **Above-Normal 2004 Atlantic Hurricane Season Predicted**
  Press Release . . . 2004 Atlantic Hurricane Outlook
- **NOAA's National Weather Service and National Sea Grant Program, in partnership with the United States Lifesaving Association, are working together to raise awareness about the dangers of rip currents. More information is available at**
  Rip Currents: Break the Grip of the Rip

- **Hurricane Awareness: Aim of U.S. Hurricane Forecasters' Visit to Caribbean**
- **NHC/TPC Outreach and Training 2004 Class Photos**
- **Archive of news and information ...**

Current Season Summaries and Reports

Atlantic

Season Summary

Monthly Summaries: Jun Jul Aug Sep Oct Nov

Tropical Cyclone Reports

Eastern Pacific

Season Summary

Monthly Summaries: May Jun Jul Aug Sep Oct Nov

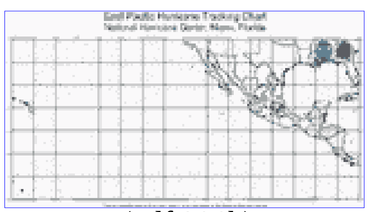
Tropical Cyclone Reports

Additional Resources

NHC/TPC Publications
Alternate Tropical Cyclone Forecast Sites
Hurricane and Natural Disaster Brochures
Real-time Weather Sites
Radiofax Broadcast Schedule
NHC/TPC External Links Index
Mariner's Guide for Hurricane Awareness (*large file* 1.3 MB PDF format)
Outreach Training Classes

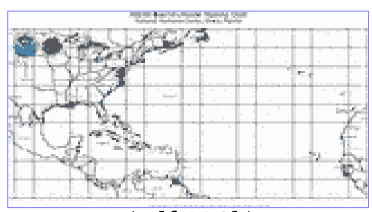
Blank Tracking Charts

Eastern Pacific



(pdf 296k)

Full Atlantic



(pdf 928k)

Western Atlantic

(pdf 110k)

These are reduced versions of the actual tracking charts used by the National Hurricane Center. You may need to install the free Acrobat® Reader to view and print them.

Tropical Cyclone, Tropical Weather, & TPC Information Topics:
Storm Information, Hurricane Awareness, Historical Information,
Tropical Analysis and Forecasting Branch, About Us, Contact Us

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National Centers for Environmental Prediction Comments/Feedback

National Hurricane Center
Tropical Prediction Center
11691 SW 17th Street
Miami, Florida, 33165-2149 USA
Page last modified: Thursday, 26-Aug-2004 18:47:48 EDT

TRACKING A HURRICANE

LESSON TITLE: Tracking a Hurricane
COURSE/GRADE LEVEL: Precalculus/Trigonometry
MATH TOPICS USED: Plotting Rectangular and Polar Coordinates
PURPOSE: to integrate the use of the Internet into instruction of Precalculus topics
REQUIRED MATERIALS:

pencils,

rectangular and polar coordinate graph paper,

graphing calculator,

hurricane tracking charts,

storm coordinate data charts,

list of weather and hurricane URLs

BACKGROUND INFORMATION:

The students should be familiar with the trigonometric conversion formulas from rectangular to polar form and back again. They should also have rectangular coordinate and polar coordinate graph paper, and be familiar with the definitions of latitude and longitude.

LESSON PROCEDURE:

Distribute storm coordinate data charts, hurricane tracking charts, and graph paper (if necessary). Hurricane Coordinates

The students will plot the hurricane coordinates given in the data chart on their rectangular coordinate graphing paper.

The students will convert one set of the coordinates from the hurricane data chart into polar coordinate form, and plot this on their polar coordinate graph paper. This reference point will act as "the eye" of the hurricane on your graph map.

We will use these coordinates to calculate the wind velocities at various distances away from the eye, given the wind velocity nearest the eye.

INTERNET SUPPORT

NIFTY WEATHER LOCATIONS:

Current Weather Maps/Movies
Florida Explores Network

INFORMATION ON TROPICAL STORMS AND HURRICANES:

Tropical Cyclones
National Hurricane Center
Earthwatch
Hurricane Imagery Page
UTMB-Galveston Hurricane Page

Cadet section

Cadet Lessons

We invite you to check out our growing collection of lessons exclusive to WeatherEye:

- **Climate Grades 3 - 8**
- **The Cloud Case Grades 5 - 8**
- **The Disaster Spot Grades 3 - 8**
- **Flash Flood! Grades 3 - 10**
- **Forecasting Grades 3 - 8**
- **Lightning Grades 5 - 10**

We also have found a number of lessons that are perfect for WeatherEyeCadet students.
Check out these resources:

- **Adopt-a-City South America Grades 5 -12**
- **Adopt-a-City, Weather Newspaper Grades 5-12**
- **Air Effects Weather Grades 4 - 8**
- **Broadcasting the Weather Grades 4 - 8**
- **Cloud Types Grades 2 - 5**
- **Earth's Atmosphere Grades 4 - 8**
- **Forecasting the Weather Project Grades 4 - 8**
- **Hurricane Project, Athena Program Grades 2 - 8**
- **Observing the Weather Grades 4 - 8**
- **Observing the Weather Grades 2 - 4**
- **Plotting the Weather Grades 4 - 8**
- **Soil Investigation, Globe Program Grades 4 - 12**

- **The Martian Sun-Times Grades 5 - 12**
- **Weather Charting Grades 5 - 12**
- **Weather Charting: International Grades 4 - 12**
- **Weather Here and There Projects Grades 4 - 8**

Cadet Main Page · Home Page · Expert Section · Teachers' Lounge · Parents' Center

WeatherEye is a public service of KGAN and is sponsored by Central Iowa Power Cooperative (CIPCO). Click on Louie the Lightning Bug for electrical safety information and the Electric Universe.

Expert section

Our WeatherEye Lessons

Nature's Challenge

Can you deal with nature? Nature has awesome power and guarded secrets. Are you up to the challenge?

These WeatherEye lessons will let you deal with the power and discover the secrets. You'll face off against real-world situations.

Hang on! We're going to put you face to face with the world's most powerful forces... and let you deal with them.

- Blizzard Attack Grades 7 - 12
- Dateline: El Niño Grades 8 - 12
- Flash Flood! Grades 3 - 10
- Global Warming Grades 7 - 12
- Handle a Hurricane Grades 7 - 12
- Lightning Grades 5 - 9
- Thunderstorms: A Recipe Grades 8 - 12
- Tornado Watch Grades 6 - 12
- SuperStorm '93, a case study (UIUC)
- Trusting the Forecast, the art of weather forecasting (UIUC)

Expert Main Page • Home Page • Cadet Section • Teachers' Lounge • Parents' Center

The New York Times on the Web Learning Network
Teacher Connections

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Test Prep Question of the Day
Web Explorer
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Letters to the Editor
Ask a Reporter
Web Navigator

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Conversation Starters
Family Movie Guide
Vacation Donation Plan
Discussion Topics

Site Guide
Feedback
Job Opportunities

Go to The New York Times on the Web

DAILY LessonPlan

Developed in Partnership with the Bank Street College of Education in NYC

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Related Article
Relief Effort in Honduras Needs Help, Officials Say
By JAMES C. McKINLEY Jr.
(Go to Article.)

Wednesday, November 4, 1998

The Wrath of Hurricane Mitch

Devastating a Country's People and Infrastructure: A Social Studies Lesson Plan

Author(s)
Alison Zimbalist, The New York Times Learning Network

Grades: 6-8, 9-12
Subjects: Current Events, Geography, Social Studies
Interdisciplinary Connections

Overview of Lesson Plan: In this lesson, students investigate how hurricanes and other natural disasters can devastate the elements of the infrastructure of a country, as well as the lives of its people. Students then work in committees, each focused on one element of a country's infrastructure, to analyze the existing infrastructure problems in Honduras caused by Hurricane Mitch, devise possible solutions for these problems, and assess how each aspect of a country's infrastructure is interdependent to the others. Students also determine how lesser developed countries and developed countries differ in times of catastrophe.
Review the Academic Content Standards related to this lesson.

Suggested Time Allowance: 1 hour

Objectives:
Students will:
1. Brainstorm how different aspects of a country's infrastructure would be affected by massive flooding.
2. Compare the land, resources, populations, and economies of Honduras and the United States to analyze how a hurricane or other natural disaster would affect the basic infrastructures of those countries differently.
3. Read and discuss "Relief Effort in Honduras in Dire Need of Resources."
4. Work in committees focusing on a specific aspect of the infrastructure of Honduras to analyze the country's existing problems caused by Hurricane Mitch, devise possible solutions for these problems, and assess how each aspect of the infrastructure is interdependent to the others.
5. Present their committee's ideas and discuss how the Honduran government may begin rebuilding their country.
6. Write a reflective journal about how the many elements of a country's infrastructure are intertwined and how and why natural disasters are handled differently in lesser developed countries than they are in developed countries.

Resources / Materials:
-classroom blackboard
-pens/pencils
-student journals
-paper
-copies of "Honduras" from the Encarta Online Concise Encyclopedia (http://encarta.msn.com) (one per student)
-large world map or globe
-copies of "Relief Effort In Honduras Needs Help, Officials Say" (one per student)

Activities / Procedures:
1. WARM-UP/ DO-NOW: Students are asked to imagine that there is an enormous flood covering an entire country in several feet of water. The class then brainstorms about how the flood may affect the following aspects of the infrastructure of that country: commerce/trade, food supply, health care/disease prevention, communication/roads, shelter, power supply. The teacher writes student responses on the board in columns (a column labeled "commerce/ trade," a column labeled "food supply," and so on.) The teacher then tells students that today they will be investigating how these aspects of life in Honduras have been devastated by Hurricane Mitch in recent weeks.

2. Students receive copies of the article on Honduras from the Encarta Online Concise Encyclopedia. A student should read the Introduction, Land and Resources, Population, and Economy sections aloud, and the class should discuss the corresponding questions below:
a. Introduction/Land and Resources: Find Honduras on a large world map or a globe. What aspects of Honduras's geography may induce massive flooding in the event of a hurricane? Compare the total area of Honduras to that of the United States (9,629,047 sq. km, or 3,717,796 sq. mi.) How might the size of a country affect the proportion of the population and geographic area subject to devastation and in need of aid in the event of a hurricane or other natural disaster?
b. Population: The population of the United States is 267,954,767 (according to a 1997 estimate). How many people per square mile is this? (approximately 72). How many people per square mile live in Honduras? (approximately 132) How do these numbers affect the potential impact of a major hurricane in Honduras compared with the United States? The Encarta article states that about 55% of the population of Honduras lives in rural areas. How might those people be affected differently by a hurricane than those living in urban areas?
c. Economy: What are the principle goods that sustain the economy in Honduras, and how would these industries be affected by major hurricanes and floods?

3. Read and discuss "Relief Effort in Honduras in Dire Need of Resources," focusing on the following questions:
a. The official death toll in Honduras was, at the time this article was printed, 362. The estimated death toll, however, was projected to be at least 5,000. Why would there be such great disparity in these numbers?
b. Using the article for reference, discuss how the following aspects of Honduras' capital city of Tegucigalpa are affected by Hurricane Mitch and the mudslides and flooding it is causing, and the impact of this devastation: roads and bridges, housing, factories, hospitals, prisons, food supplies, sewer systems, potable water.
c. Why are military officials having difficulty rescuing people in remote areas? What types of equipment do they lack?
d. How is the fact that Hurricane Mitch is hovering over bodies of water, rather than land, affecting the amount of rainfall being dropped on Honduras?
e. What type of "help from abroad" do Hondurans need to survive this catastrophe?

4. Divide students into six groups, one for each of these areas: commerce/trade, food supply, health care/disease, communication/roads, shelter, and power. Tell each group that it is a committee established to deal with a specific area of the infrastructure of Honduras being affected by the devastation caused by Hurricane Mitch. Each group must discuss and take notes on their answers to three questions:
--What problems exist in your specific area of the infrastructure of Honduras due to the devastation caused by Hurricane Mitch?
--What solutions can your committee propose to attempt to solve these problems?
--How does your committee's area relate to each of the other areas of the infrastructure of Honduras?
Groups should refer to the notes written on the board from the first activity, the Encarta article on Honduras, and the New York Times article for assistance.

5. Each committee presents its group's ideas to the class. After all committees have presented, wrap up the discussion by asking students how they think the government of Honduras will work towards rebuilding these aspects of the country.

6. WRAP-UP/ HOMEWORK: In their journals, students write a reflective response to the lesson. How are different aspects of a country's infrastructure intricately intertwined? What are some of the essential differences between how hurricanes and other natural disasters affect lesser developed countries (like Honduras) and developed countries (like the United States)? Why do these differences exist?

Further Questions for Discussion:
--What is a hurricane, and how does it differ from other types of storms?
--How do hurricanes form?
--What areas are often hit by hurricanes, and why are these locations prime targets because of their geographical features?
--How are hurricanes forecasted, and what surveillance methods are used to watch the progress of hurricanes?
--How can people prepare for a hurricane?
--What government services are available in the United States to help areas affected by weather disasters?
--What other forms of aid do those affected by weather disasters in the U.S. receive?
--Why are people often reluctant to leave an area where a hurricane is predicted to hit?
--What aspects of a country's infrastructure may be affected by a hurricane or other natural disaster?
--How might the size of a country affect the proportion of the population and geographic area subject to devastation and in need of aid in the event of a hurricane or other natural disaster?
--How might people living in a rural area be affected differently by a hurricane from those living in urban areas?
--What industries might be affected by major hurricanes and floods?
--How do the various elements of a country's infrastructure affect the other elements of that country's infrastructure?
--In what ways can governments rebuild their countries following a natural disaster?
-- What are some of the essential differences between how hurricanes and other natural disasters affect lesser developed countries (like Honduras) and developed countries (like the United States), and why do these differences exist?

Evaluation / Assessment:
Students will be evaluated based on participation in class brainstorm and discussion activities, participation in small group committees, and reflective journal responses.

Vocabulary:
meager, catastrophic, torrential, remote, relentless, impoverished, inundated, debris, evacuate, potable, havoc, abroad

Extension Activities:
1. Students can learn about floods and hurricanes that devastated portions of the United States (the 1993 floods in the Midwest, Hurricane Andrew, Hurricane Hugo) and research the methods that were used to rebuild these areas. Students should also compare resources available in the United States to those currently available in Honduras.

2. Students can research other types of natural disasters (e.g., volcanoes, earthquakes, tornadoes, tsunamis, forest fires, blizzards, droughts), focusing on how these disasters are predicted, how one can protect oneself in these disasters, and famous examples of these disasters.

3. Students can learn about how the geography of an area influences frequent flooding, mudslides, and other water-related destruction.

4. Students can search the Internet for the Web sites of organizations that assist flood and hurricane victims in the United States and worldwide.

5. Students can keep an on-going scrapbook of newspaper articles about the floods in Honduras or about the devastation caused by Hurricane Mitch. Each article

should be clipped and taped to a notebook page, and students should summarize and offer opinions of the articles.

6. Students can keep a photojournalism notebook of news photographs of the floods in Honduras or of the destruction caused by Hurricane Mitch. The class can also devote a bulletin board to photos and news clippings following this disaster and the relief efforts being put in place.

7. Students can organize a community aid drive for the victims of the floods in Honduras and other countries affected by Hurricane Mitch. Students can contact local relief organizations for support or to volunteer to participate in community efforts.

Interdisciplinary Connections:
American History: Students can research natural disasters that occurred in the United States and the relief organizations and government programs that assisted the victims and helped to rebuild the land and the communities.

Global History: Students can learn about the country of Honduras, focusing on its government, economy, and culture.

Language Arts: Students can write a reflective essay about their reactions to the devastation caused by Hurricane Mitch. As a prompt, students may want to select photographs from the newspaper and respond to those specific images.

Mathematics: Students can create a chart comparing the economies, population, size, and other statistics about the United States and Honduras. What resources might the United States have that Honduras does not? What do these statistics demonstrate about potential differences in aid for natural disaster victims?

Media Studies- Students can assess how the media is covering Hurricane Mitch by keeping a daily log of news reports from television, radio, or a newspaper. How are these media covering the same event differently? If Spanish television news shows or newspapers are available in your part of the country, how are these media presenting the news about Hurricane Mitch? What similarities and differences exist?

Science- Students can study the "science" of hurricanes. Students can also research diseases that develop due to polluted water supplies (cholera, Bubonic plague, etc.).

Technology- Students can learn about different meteorological equipment that assists in measuring and tracking hurricanes and other storm systems.

References:
"United States of America," Encarta Online Concise Encyclopedia (http://encarta.msn.com)

Other Information on the Web
The National Weather Service: (http://www.nws.noaa.gov/om/hurrbro.htm)

The National Hurricane Center: (http://www.nhc.noaa.gov/)

Hurricane & Storm Tracking, Atlantic and Pacific Oceans: (http://hurricane.terrapin.com/)

Are You Ready for a Hurricane?: http://www.redcross.org/disaster/safety/hurrican.html

Hurricane: Storm Science: http://www.miamisci.org/hurricane

53rd Weather Reconnaissance Squadron: The Hurricane Hunters: http://www.hurricanehunters.com

The American Red Cross: http://www.redcross.org

Academic Content Standards:

MCREL This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the

Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8
Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows factors that can impact the Earth's climate; Knows the processes involved in the water cycle
Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmark: Knows the consequences of a specific physical process operating on Earth's surface
Geography Standard 12- Understands the patterns of human settlement and their causes. Benchmarks: Knows the similarities and differences in various settlement patterns of the world; Knows ways in which both the landscape and society change as a consequence of shifting from a dispersed to a concentrated settlement form (e.g., a larger marketplace, the need for an agricultural surplus to provide for the urban population, the loss of some rural workers as people decide to move into the city, changes in the transportation system);
Knows the internal spatial structures of cities (e.g., the concentric zone model and the sector model of cities; the impact of different transportation systems on the spatial arrangement of business, industry, and residence in a city)
Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Knows the ways in which human systems develop in response to conditions in the physical environment; Knows how the physical environment affects life in different regions; Knows the ways people take aspects of the environment into account when deciding on locations for human activities; Knows the effects of natural hazards on human systems in different regions of the United States and the world; Knows the ways in which humans prepare for natural hazards

Grades 9-12
Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows that weather and climate involve the transfer of energy in and out of the atmosphere; Knows how winds and ocean currents are produced on the Earth's surface
Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmarks: Understands the distribution of different types of climate that are produced by such processes as air-mass circulation, temperature, and moisture; Understands the effects of different physical cycles on the physical environment of Earth; Understands how physical systems are dynamic and interactive; Understands how physical processes affect different regions of the United States and the world
Geography Standard 12- Understands the patterns of human settlement and their causes. Benchmarks: Knows the shape of cities in the United States and factors that influence urban morphology (e.g., transportation routes, physical barriers, zoning regulations); Knows the similarities and differences in settlement characteristics of economically developing and developed nations (characteristics of cities; residential and transportation patterns; travel distance to schools, shopping areas, and health care facilities); Knows the consequences of factors such as population changes or the arrival/departure of a major industry or business on the settlement patterns of an area (e.g., stress on infrastructure, problems of public safety and fire protection, crisis in delivering school and medical services)
Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Understands how people who live in naturally hazardous regions adapt to their environments; Knows factors that affect people's attitudes, perceptions, and responses toward natural hazards

Send feedback on this lesson.

Browse or search the lesson plan archive.

Curricular Resources in Weather and Climate

Below are the CLN "Theme Pages" which focus on specific topics within Weather and Climate. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality Theme Page
- Blizzards and Snow Theme Page
- Clouds Theme Page
- El NiñoTheme Page
- Floods Theme Page
- Global Warming/Climate Change Theme Page
- HurricanesTheme Page
- LightningTheme Page
- Ozone Depletion Theme Page
- TornadoesTheme Page
- Water Quality Theme Page

General Weather/Climate Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Weather/Climate. Please read our disclaimer.

- About Rainbows

  Answers to various questions about rainbows for older students, including: What is a rainbow? Where is the sun when you see a rainbow? What makes the bow? What makes the colors in the rainbow? What makes a double rainbow? and more...

- Ask an Expert: Weather

  CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on Weather may be found in our "All Subjects" section at the top of the page, the "Science" section, as well as the general "Reference" section.

- [Athena Curriculum: Weather]

Athena has used geophysical and other data sets acquired via the Internet to prepare curricular units on weather. Included are instructional materials, links to education programs, and resource materials (e.g., maps).

- [The] Atmosphere: A Delicate Situation

This site contains information and links which allow students to learn about the fundamental principles of the atmosphere, for example its composition and structure. Student activities are included as well.

- Bad Meteorology

Detailed explanations of the faulty reasoning behind commonly taught misinformation about weather (e.g. formation of clouds, shape of raindrows, greenhouse effect, and rotation of draining water-Coriolis effect).

- Earth and Environmental Science

The U.S. Geological Survey maintains a meta-list of links to resources on Climate.

- Exploring the Environment: Weather or Not

This module is part of "Exploring the Environment"[a] (ETE) from NASA's Classroom of the Future[a]. In ETE, high school students are faced with a real life problem and their goal is to use problem solving skills and internet based data (e.g., remotely sensed satellite images) to propose and defend a solution. A Teacher's Guide is available. This link is to the ETE home page since it gives the easiest access to necessary introductory and teacher information. To access the weather module, click on "Modules and Activities" and then "Weather or Not."

- Forecasting

This interactive lesson, designed for grades 2-6, explains modern forecasting techniques, contains an online quiz, and provides an activities page that encourages students to practice the forecasting tricks they have learned and to observe the weather.

- Fundamentals of Physical Geography

Although this online textbook from Michael Pidwirny, Okanagan University College, is intended for postsecondary students studying introductory physical geography, much of it may be applicable for high school students as well. Contents include over two hundred pages of information, more than three hundred 2-D and animated graphics, an interactive glossary of terms, a study guide, links to other Internet resources, and a search engine. See the Table of Contents to directly access such sections as Meteorology and Climatology, Hydrology, Biogeography and Ecology, Geology, and Geomorphology.

- [The] OnlineGuides

Formerly known as the "Guide to Meteorology" and/or "The Daily Planet", these resources from the Department of Atmospheric Sciences at the University of Illinois contain instructional resources on meteorology, remote sensing, and reading and interpreting weather maps. They also have a section titled "Projects and Activities" with curriculum aids for teachers.

- [Severe Weather]

  Here, students will be able to obtain information on severe storms, tornadoes and hurricanes as well as pursue links to other severe weather sites.

- [UM Weather]

  Another metalist of links to weather related sites, but the categorization of those links from the University of Michigan is somewhat unique. In addition to the standard categories of links to weather forecasting sites (including Canada as a separate category), you'll find links to site that have radar/satellite imagery, tropical weather, weather maps, and weather software.

- [[The] Weather Dude]

  A weather page especially for kids, parents and teachers from Seattle's KSTW-TV. There are links to explanations of weather terminology, links to teacher/parent resource materials on weather and other sciences, and links to resource materials where kids can learn more about weather and other sciences.

- [WeatherOffice (Environment Canada)]

  A clickable map with locations around Canada, United States, or the World leads to local weather forecasts. Unfortunately, the site is limited to use by frames-based browsers. Canadian weather forecasts and current conditions are also available at this other, less sophisticated Environment Canada site.

- [Weather: The Final Front]

  Here's a meta-list of links to pages of weather resources designed for K-12 students and teachers by a Northern Ontario Consortium. Their categories of weather resources (each with extensive set of links) include: air, atmosphere, climate, interpreting the weather, precipitation, water cycle, and weather in general.

- [World Climate Data]

  Links to weather stations around the worlds are found in abundance at this site. You can find climate data by country, by placename or by WMO name. Note that the data are on climate, not on current weather conditions.

- [WWW Virtual Library: Meteorology]

  Here's a meta-list of links to meteorological sites, organized by data index, geographical index and server type.

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Note: The sites listed above will serve as a source of curricular content in Weather/Climate. For other resources in this subject area (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Electricity (Concepts) Theme Page

Below are the CLN "Theme Pages" that support the study of electricity and magnetism. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans), which will help teachers provide instruction in this theme.

- Electronics (Circuitry) Theme Page
- Lightning Theme Page
- Magnetism Theme Page

General Electricity Resources

Here are a number of links to other Internet resources that contain information and/or other links related to the concepts of electricity. Please read our disclaimer.

- AC/DC what's the Difference

  A PBS website that uses animation and simple explanations as an introduction to the principles of electricity.

- Articles on "Electricity"

  The author of this site has many articles that describe and discuss a number of interesting electricity related concepts. Some of the articles present information on topics such as: common misconceptions of electricity, what is electricity, lightning, static electricity, and more. Also included on this page are plans for more than fifteen simple electrical devices.

- AskERIC Lesson Plans: Physical Sciences

  The link is to AskEric's Physical Science page, if you wish to browse/search their site yourself. Or, use the links below to go directly to some lesson plans specifically about electricity/magnetism.

  - Attracting Balloons Static electricity for intermediate students.
  - Brown Bag Science This lesson plan, designed for grade 1-5 students, will help learners investigate and understand the concept of electricity. Students draw and construct simple circuits using the vocabulary associated with electricity.
  - Static Electricity Intermediate students use an inquiry method to learn about static electricity.

- [The] Atoms Family

  Designed for K-8 students, this site uses the "The Adams Family" characters as metaphors. For broad topics related to electricity including: kinetic and potential energy; atoms and matter; conservation and energy transfer; and light, waves and particles. The following link is direct to their pages on electricity.

- Frankenstein's Lightning Laboratory Here's a page on electrical safety and two electricity experiments.)

- ## Bizarre Stuff You Can Make In Your Kitchen

This site is an ever growing warehouse of the kinds of projects some of the more demented of us tried as young people, collecting in one place many of the classic, simple science projects that have become part of the collective lore of amateur science. It is a sort of warped semi-scientific cookbook of tricks, gimmicks, and pointless experimentation, concoctions, and devices, using, for the most part, things found around the house. These are the classics. Strange goo, radios made from rusty razor blades, crystal gardens... amateur mad scientist stuff. If you happen to learn something in the process, consider yourself a better person for it.

- ## [The] Electric Pickle

By using electricity in an experiment, this site shows the "how to and why" the phenomenon of the glowing pickle occurs.

- ## Electricity and Magnetism

More than a dozen experiments on electricity and magnetism designed for intermediate students.

- ## Elements of AC Electricity

A collection of tutorials presenting a wide range of topics in electricity. These topics include: AC Waveform, Inductance, Inductor Circuits, Direct-Current RL Circuits, Inductive Reactance, and many more.

- ## Just For Kids

This site has information about electricity and safety, energy and water experiment, games, and links to other exciting Websites.

- ## Physical Science Activity Manual

This Manual contains 34 hands-on activities that can be downloaded in either MAC (MS WORD) or Windows (WordPerfect) versions. Individual chapters may be downloaded by clicking the appropriate version beside the title.

- ## Learning About Renewable Energy

Consumer Energy Information Fact Sheet; a complete dissertation from the U.S. Dept. of Energy about renewable energy sources. The site has a glossary and links to other sites for more information.

- ## Power Failure

In this lesson plan, grade 5 students learn about the importance of electricity to societies in the world by using the Internet to collect data from keypals.

- ## Project PHYSLab

Project PHYSLab has a collection of high school physics labs (including some for Electricity) developed by participants in an annual, three-week workshop. This link is to the home page of the project. From there, enter "Labs Available Online" to find the labs. Since each of these is done by a different teacher, the quality of the lab and the detail associated with it will vary.

- Science Lab

Here's a collection of science experiments that explore various physics concepts within the oil industry. Experiments have a teacher's guide and can be related to informational articles within the site's "Science Watch." Electricity-related experiments are Building an Electrical Logging Tool and the Electrical Resistivity of Materials.

- Smile Program Physics Index

Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has over 30 lesson plans in their section on Electricity and Magnetism. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- Snacks about Electricity

"Snacks" from the Exploratorium are miniature science exhibits that teachers can make using common, inexpensive, easily available materials. This page has about a dozen activities/experiments on electricity.

- Static Electricity Page

A Website full of projects, articles and forums about static electricity.

- Theater of Electricity

Using a Van de Graaff generator as a source of electricity, the site has a number of pages demonstrating some of the behavior of electricity. The generator creates static electricity and is studied in different experiments simulating lightning. After viewing the site, you can interact with a lightning safety quiz. The following link is to the site's collection of lesson activities.

  - Activities to Explore Static Electricity More than five comprehensive lesson activities and a page of background information for teachers.

- Virtual Labs and Simulations

Here's a collection of links to sites on the Web that have computerized simulations of physics principles that allow students to see a visual demonstration of a scientific concept, often in animated form. In addition, the student may be given the opportunity to manipulate one or more variables underlying the concept and then witness the changes. There are about 30 labs/simulations in electricity. Labs cover topics in Ohm's law, circuits, Kirchhoff, resistors, measurement, charge, force, field, and more.

- "Watt's" on Your Mind

Help Dr. Frank N. Stein bring the monster to life by having students participate in the interactive game. A great site for elementary grades about wasting energy.

- [Watts Up With the Heat?]

In this lesson plan, grade 6-12 students "create a variety of simple, series, and parallel electrical circuits to illustrate how electricity flows through different types of basic circuits and to understand the practical applications of these types of circuits. Students then apply their knowledge of electrical circuits to the loss of power in the midst of July 1999's heat wave, determining how electrical power systems fail in extreme heat, how "load shedding" is used to reduce strain on power sources, and how power outages can be prevented in the future." They use a New York Times article as a starting point for their explorations.

- [What is Static Electricity?]

Static electricity is described in terms of atoms, electrical charges, conservation of charge, and Coulomb's Law. Designed with middle and high-school students in mind, the "I CAN READ" section is for students with low reading skills. The page includes four hands-on projects teachers can try with their students.

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Note: The sites listed above will serve as a source of curricular content in Electricity (Concepts). For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu, which will give you access to educational resources in all of our subjects.

Previous Screen

Electronics (Circuitry) Theme Page

Below are the CLN "Theme Pages" which support the study of electricity and electronics CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Electricity (Concepts) Theme Page

General Electronics (Circuitry) Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Electronics. Please read our disclaimer.

- Basic Electronics

  Electronics author John Adams aims this site at those who seek basic electronics knowledge with minimal theory.

- Bowden's Hobby Circuits

  More than 60 electronic circuit designs for hobbyist or student. Most circuits can be built with common components purchased locally. Also, the site has links to other hobby electronic sites and electronic related software.

- Electronics: An Online Guide For Beginners

  Basic concepts of electronic theory are introduced. The site introduces breadboard, soldering, discusses series and parallel circuits, and provides schematic diagrams for various electronic projects.

- How to Become An Antenna Guru

  A page describing what an antenna is in terms of its transmission line, impedance, radiation pattern, polarization and arrays. The author includes many illustrations along with descriptions.

- Iguana Labs

  A collection of tutorials for the beginner, intermediate and advanced learner. Information includes basic concepts and components, determining resistor values by reading its colour codes, using breadboards, Ohm's Law, LEDs, transistors and multimeters.

- Interfacing the PC

  A tutorial that teaches you how to connect anything electronic to your PC using common interfaces such as the Serial and Parallel Ports.

- Internet Guide to Electronics

The author of this site states it is designed for beginners. Some of the content includes basic topics like: Circuits, Voltage, Current, Resistance, Ohm's Law, Ohm's Calculations and much more.

- The Transistor

  Lucent Technologies, which used to be AT&T Bell Labs, hosts this site about the development of the transistor and how it works.

- Tomi Engdahl's Electronics Info Page

  A meta-list of electronic related sites. The author has an organized, comprehensive list of links to electronic and PC hardware, many supporting documents and a few dozen circuit schematics.

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Note: The sites listed above will serve as a source of curricular content in Electronics (Circuitry). For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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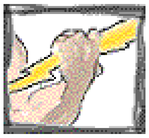


Bright Light Fright

One of the most powerful forces in nature, lightning was once magical, mysterious, and misunderstood. Historically, myth and legend accounted for lightning with stories of angry gods and heroes. Today, meteorologists uses lightning as a tool for analyzing and forecasting the intensity and movement of thunderstorms. While lightning is still a little mysterious, meteorologists now understand it and know how to prepare for it. Of course, every once in a while lightning does still put on a magic show.

To understand a little of lightning's magic, take a look at **Lightning History**, **Lightning Science**, and **Lightning Detection**.

Inform Inspire Involve
science.nasa.gov
Space Science News home

Human Voltage

What happens when people and lightning converge

June 18, 1999: Either lightning is attracted to testosterone, or men spend an inordinate amount of time outdoors swinging metal objects about. Men are struck by lightning four times more often than women.

One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

According to a study entitled "Demographics of U.S. Lightning Casualties and Damages from 1959 - 1994," by Ronald L. Holle and Raúl E. López of the National Severe Storms Laboratory and E. Brian Curran of the National Weather Service, males account for 84% of lightning fatalities and 82% of injuries.

Men can take comfort in the fact that the actual number of deaths and injuries from lightning strikes has decreased in the past 35 years. Holle's team attributes 30 percent of the decrease in lightning deaths to improved forecasts and warnings, better lightning awareness, more substantial buildings, and socioeconomic changes. They attribute an additional 40 percent to improved medical care and communications.

The National Weather Service publication *Storm Data* recorded 3,239 deaths and 9,818 injuries from lightning strikes between 1959 and 1994. Only flash floods and river floods cause more weather-related deaths. But according to Dr. Elisabeth Gourbière of the Electricité de France, Service des Etudes Médicales, only 20 percent of lightning victims are immediately struck dead. Still, many doctors do not fully understand how to treat the injuries of the other 80 percent

Recent Headlines
October 29: A Swift Look at the Biggest Explosions in the Universe
October 27: Leonids in the Crystal Ball
October 26: Chandra Spies Structure of Huge X-Ray Jets
October 25: Postmortems in the Sky

of lightning victims who survive a strike.

Says Gourbière, "The pathology of lightning, or keraunopathy, is known only to a few specialists."

Most doctors are more familiar with electrical shocks, such as those received by industrial workers when they have an accidental run-in with high-voltage equipment. But lightning injuries are not the same as electrical shocks. For one thing, the contact voltage of a typical industrial electrical shock is 20 to 63 kilovolts, while a lightning strike delivers about 300 kilovolts.

Industrial shocks rarely last longer than half a second (500 milliseconds) because a circuit breaker opens or the person is thrown far from the live conductor. Lightning strikes have an even shorter duration, only lasting up to a few milliseconds. Most of the current from a lightning strike passes over the surface of the body in a process called "external flashover."

Both industrial shocks and lightning strikes result in deep burns at point of contact - for industry the points of contact are usually on the upper limbs, hands and wrists, while for lightning they are mostly on the head, neck and shoulders. Industrial shock victims sometimes exhibit deep tissue destruction along the entire current path, while lightning victims’ burns seem to center at the entry and exit points. Both industrial shock and lightning victims may be injured from falling down or being thrown, and the leading cause of immediate death for both is cardiac or cardiopulmonary arrest.

If you survive a shock, you still have to deal with the consequences of the electrical burns. Industrial shock burns can lead to kidney failure, infection, muscle and tissue damage, or amputation. Lightning burns are exceptionally life threatening (see box at the end of this story).

Right: High voltage electrical equipment can cause severe shocks and burns slightly similar to those from lightning strikes.

Gourbière says that 70 percent of lightning survivors experience residual effects, most commonly affecting the brain (neuropsychiatric, vision and hearing). These effects can develop slowly, only becoming apparent much later.

Feel the Burn

If you'd like to experience a lightning strike, go golfing one Sunday in July around 4 p.m. If you're really determined, be sure you do it in Florida.

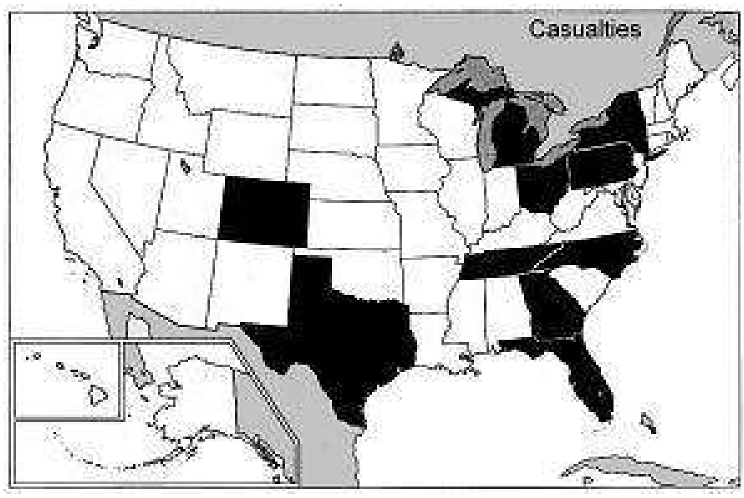
Florida has twice as many lightning casualties (deaths and injuries combined) as any other state. Most lightning casualties occur in the afternoon - two-thirds between noon and 4 p.m. local standard time with a casualties maximum at 4. Sunday has 24% more deaths than other days, followed by Wednesday. Lightning reports reach their peak in July.

Many lightning victims had been walking in an open field or swimming before they were struck. Other lightning victims had been holding metal objects such as golf clubs, fishing rods, hay forks, or umbrellas. But even those not holding metal objects are as likely to be struck by lightning as a bronze statue of the same size.

When you hear thunder, you are already within the range where the next ground flash may occur. N. Kitagawa of Central Lightning Protection, Inc. and A. Sugita and S. Takahashi of Franklin Japan determined the average intervals between lightning strikes in order to estimate how much time someone has to seek shelter. Their news is far from encouraging.

"It is concluded that there exists no safe time interval during which a human is free from direct strikes," they wrote.

In an area with a radius of 500 meters (1,640 ft), most of the intervals between lightning strikes range from 0 to 600 seconds, with a maximum frequency of 40 seconds.



Right: The top ten states in number of lightning casualties (deaths and injuries combined). Florida leads the list, with twice as many casualties as any other state. Other states represented are Georgia, Tennessee, North Carolina, New York, Pennsylvania, Ohio, Michigan, Colorado and Texas.

To avoid being struck by lightning, you should seek shelter when you hear even the faintest thunder. Some of the best places to take refuge are enclosed buildings, or cars and buses (but don't touch the metal!). In case there are no safe spaces nearby, bend into a crouching position until there is a break in the storm.

Web Links
Lightning Strike Survivors Resource Page - links to survivors' stories and other lightning pages.
National Lightning Safety Institute
National Severe Storms Laboratory
NASA's Global Hydrology and Climatology Center - Lightning and atmospheric electricity research.

Isolated trees, telephone booths, and open structures like gazebos or porches make poor lightning shelters. If there is a tall object nearby, move as far away as possible - at least 2 meters (7 ft). Standing next to tall isolated objects like poles or towers makes you vulnerable to secondary discharges coming off those objects.

The mechanism for how towers attract lightning is not really understood. But scientists have known for a long time that towers attract more lightning than the undisturbed ground nearby.

The tale of a family in North Carolina clearly illustrates how towers can concentrate lightning strikes. In 1998, a 42 meter (138 ft) tall water tower was erected near Murfreesboro, NC. This tower was about 45 meters away from a farmhouse that was situated on a one acre plot in a large open area of farmland. The family had lived in the farmhouse for the past 10 years, and they had never experienced any lightning damage. After the tower was erected, 5 separate discharges near the house occurred over a period of 5 months, causing the deaths of 2 trees, a fire in electrical equipment, complete destruction of all phone wiring, and damage to electrical fixtures.

Right: Lightning flirts with a 335-ft tall radio tower. Credit: Jeffrey K. Herzer/Missouri State Highway Patrol Communications Division.

Lightning damages have been on the increase in the past 35 years. Holle's team attributes most of this increase to population growth. *Storm Data* recorded 19,814 property-damage reports due to lightning in the United States from 1959-1994. Pennsylvania has the largest number of damage reports, while the highest rates of damage reports weighted by population are on the plains from North Dakota and Oklahoma.

According to Richard Kithil of the National Lightning Safety Institute, most reports of the economic impact of lightning are contradictory and underreported. The National Weather Service *Storm Data* figures place the most recent yearly losses at $35 million, but the process by which this figure is tabulated is open to error. *Storm Data* collects much of its severe weather information from newspaper reports. If an incident is not reported in the paper or is overlooked by the *Storm Data* reviewer, it may not get into the publication's statistical base.

Kithil conducted his own study based on insurance reports and other sources that keep track of weather damages, and he came up with a much larger figure for the annual cost of lightning strikes.

"It seems reasonable to estimate that there may be $4 to 5 billion in lightning costs and losses each year in the US," said Kithil.

There are currently several different methods used to keep track of lightning strikes, but none of them can be considered perfect. Medical reports, for instance, sometimes report "burns" as the primary cause of death, with lightning listed as a secondary effect. Despite such instances of underreporting, the methods used in the United States to track lightning strikes are considered to be the best available.

"We work with people from other countries who wish they had what we have," said Holle.

Humans versus Lightning

To stand against the deep dread-bolted thunder?
In the most terrible and nimble stroke
Of quick, cross lightning?
(Wm. Shakespeare, "King Lear", Act 4, Scene 7)

Right: Photo Credit: Australian Severe Weather/Michael Bath

In the contest between people and lightning, lightning wins. Although lightning rarely strikes more than one person at a time, over the course of a year the damages, deaths and injuries add up to make lightning a serious threat. By studying the outcome of human-lightning encounters, scientists hope to find more ways to prevent such meetings from occurring in the first place.

Most Typical Disorders Associated with Lightning Strikes

(from "Lightning Injuries to Humans in France" by Dr. Elisabeth Gourbière of the Electricité de France, Service des Etudes Médicales)

Lightning deaths (~20%)
-Asystole/Ventricular fibrillation
-Inhibition of brainstem respiratory centers
-Multi-system failure (delayed death)

Cardio-pulmonary injuries
-Arrhythmias - Arterial pressure changes
-Electrocardiographic changes
-Myocardial damages (infarction)
-Cardiac dysfunction
-Pulmonary edema - Respiratory distress syndrome

Neurologic/psychiatric injuries
-Loss of consciousness/coma
-Amnesia/Anxiety/Confusion/Aphasia/Seizures
-Electroencephalographic abnormalities
-Brain/Cerebellum damages
-Numbness/Weakness in limbs/Partial or complete (but temporary) paralysis
-Neuropathy/Pain syndromes
-Spinal cord injury/Parkinsonism

-Sleep and memory disorders/Concentration disturbances/Irritability/Depression/Various other disturbances such as headaches, tiring easily, lightning storm phobia, etc.
-Post traumatic Stress Disorder

Burns and Cutaneous marking
-Small, deep entry/exit points (typical)
-Contact, metal chain heating (typical)
-Superficial linear
-Flash
-Lichtenberg figures (arborescent, fern-like markings):pathognomonic(on trunk, arms, shoulders)

Clothing, shoes
-Exploded off, torn off, shredded, singed…

Blunt traumas (explosion)
-Contusion, internal hemorrhage (brain, lungs, liver, intestine…)
-(rarely) Fractures (skull, cervical spinal column, extremities…)

Auditory and ocular injuries
-Tympanic membrane ruptured (typical)
-Deafness/Tinnitus/Vertigo
-Transient blindness/Photophobia-Conjunctivitis - Corneal damage
-Retinal abnormalities (macular hole) - optic neuritis
-Cataract

"Lightning injuries are varied and take many different forms. The most dangerous (and possibly fatal) immediate complications are cardiovascular and neurologic. It must be kept in mind that only immediate and effective cardiorespiratory resuscitation (started by rescuers), followed as soon as possible by emergency medical treatment, can save victims who are in cardiopulmonary arrest, or avert the serious consequences of cerebral hypoxia. Some victims remain in a coma despite intensive resuscitation and die of secondary causes including hemorrhages and multiple lesions (encephalic, cardiac, pulmonary, intra-abdominal)."

Other lightning stories

Human Voltage (June 18,1999) What happens when lightning meets people
News shorts from Atmospheric Electricity Conference (June 16,1999) Poster papers on hurricanes and tornadoes summarized.
Soaking in atmospheric electricity (June 15, 1999) 'Fair weather' measurements important to understanding thunderstorms.
Lightning position in storm may circle strongest updrafts (June 11, 1999) New finding could help in predicting hail, tornadoes
Lightning follows the Sun (June 10, 1999) Space imaging team discovers unexpected preferences
Spirits of another sort (June 10, 1999) Thunderstorms generate elusive and mysterious sprites.
Getting a solid view of lightning (June 9, 1999): New Mexico team develops system to depict lightning in three dimensions.
Learning how to diagnose bad flying weather (June 8, 1999): Scientists discuss what they know about lightning's effects on spacecraft and aircraft.
Three bolts from the blue (June 8, 1999): Fundamental questions about atmospheric electricity posed at conference this week.

[Lightning Leaders Converge in Alabama](#) (May 24, 1999): Preview of the 11th International Conference on Atmospheric Electricity.
What Comes Out of the Top of a Thunderstorm? (May 26, 1999): Gamma-rays (sometimes).

More links

National Severe Storms Laboratory, Norman, OK
National Severe Storms Laboratory Photo Library, where we got a lot of the neat pictures for these lightning stories.

Lightning research at NASA/Marshall and the Global Hydrology and Climate Center.

More Space Science Headlines - NASA research on the web

NASA's Earth Science Enterprise Information on Earth Science missions, etc.

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return to Space Science News Home

For more information, please contact: Dr. John M. Horack , Director of Science Communications	Author: Leslie Mullen Curator: Linda Porter NASA Official: Ron Koczor

PLEASE NOTE: This web page has moved to: http://www.kidslightning.info/zaphome.htm

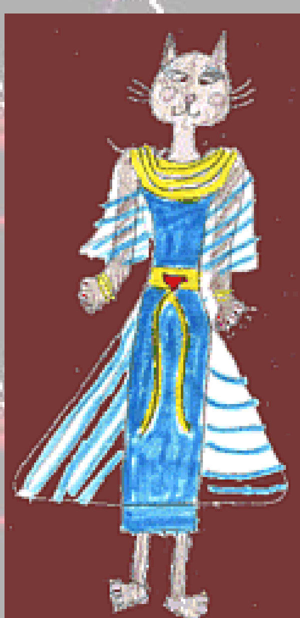
Please use this link now for the most current information.

Lightning information and safety for children - Blitzinformationen und sicherheit für Kinder - La sécurité foudre pour les enfants - Informazioni sul fulmine e sicurezza per i bambini - Informação e segurança do relâmpago para crianças - Información y seguridad del relámpago para los niños - Maelezo kuhusu radi na usalama kwa watoto.

TECHNICAL NOTES: **This web site is intended to be viewed without advertising. If you see it inside another web site or with ads, please click here.**

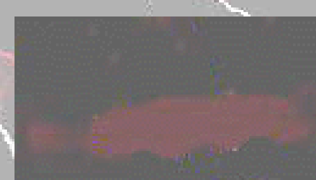
SEARCH this web site: use search engine link at the bottom of this page.
LANGUAGE TRANSLATIONS: Links at the bottom of this page can give approximate computer translations into 8 languages.

To enjoy the colors of this web site as they were created, click here for a simple MONITOR ADJUSTMENT.



KIDS' LIGHTNING INFORMATION AND SAFETY

by Sabrina



Featured in *Jack and Jill, Chemecology, American Girl, Kid City* and the Franklin Institute's exhibit: *The Powers of Nature*.

-- Please Help with my web site's address change: --
If you were refered to this web site by a friend, school, museum, organization, library, weather person, etc., and were given the old "azstarnet" address, please tell them about the new web address:

www.kidslightning.info
(www.lightningsafety.info will also work)
Thanks very much, Sabrina.

WHY I MADE THIS WEB SITE.

Please read my lightning introduction page
or ma page d'introduction sur la foudre traduite en français.

Also, I am looking for people who would be willing to help translate this web page into other languages in order to share this information with kids around the world. If you or someone you know can help with this, please send an e-mail message. Lightning stories from other kids are now in English, Spanish and Swahili, the Introduction can be read in French and parts of the web site will also soon be in Chinese.

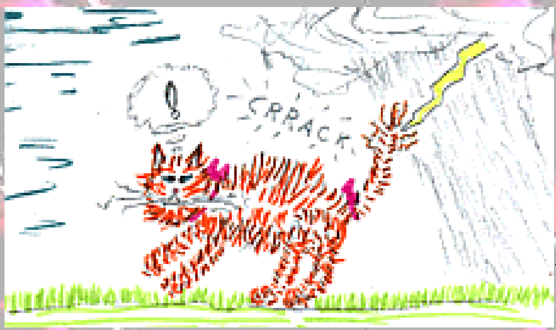
WHAT IS LIGHTNING?

Lightning is a big charge of electricity that can reach from clouds to the ground or to other clouds. It can start fires and it is strong enough to hurt or kill people. Lightning also helps nature by putting nitrogen in the ground for plants to use.

IS LIGHTNING REALLY DANGEROUS?

There are thousands of lightning strikes every day. Scientists think that lightning hits somewhere on the earth about 100 times every second. More people are killed by lightning than by any other kind of storm, including hurricanes and tornadoes. Every year, about 100 people are killed by lightning in the United States and also about 100 people in Europe. In the whole world, lightning kills more than 1,000 people in a year, maybe many more. A lot more people are hurt by lightning than are killed by it and many of those who live are hurt very badly.

What does it feel like to be hit by lightning?



To me, it felt like when your foot falls asleep, but much stronger. The pain after the strike lasted about an hour. My dad says that he felt as if he had both of his hands and arms stuck in electrical wall sockets. His feet and legs hurt and tingled for about half an hour afterward. My mom says that it felt as if someone hit her on her feet with a sledge hammer. But we were very lucky. Lightning knocks many people to the ground, some are burned and some people are unconscious after they are struck.

Many kids weren't as lucky as I was. A girl named Elizabeth, in North Carolina, was camping with other kids when they were hit by lightning. Ashlie, in California, was hit after she got off the school bus. Maria Cristina, lives in Colombia. She was hit when she was playing. You can read their stories if you click on Kids' Stories. Thanks to Maria Cristina and her family, you can also read the stories in Spanish. Gracias a María Cristina y a su familia también puedes leer estas historias en español. Historias de niños en Español. Thanks also to Kim of Kenya for making some of the kid's stories available in Swahili

Grownups have also sent me stories that can teach us about lightning. Grownups' Stories. Also, animals are sometimes hit by lightning. Kids who love horses will want to read Horse Story but be careful, it is a sad story.

WHERE CAN LIGHTNING STRIKE?

Lightning can strike almost anywhere. I think that my family and I were struck because we did not understand that many people are struck before and after the rain falls.

I have learned that lightning can strike as far as 10 miles away from a storm. In fact, scientists are now pretty sure that it can strike 15 or more miles away from a cloud. So, if there is blue sky above you and it is not raining, you still might not be safe if you can see or hear a storm in the distance. Lightning can strike anywhere in a big circle around the where the rain is falling. Click on this link to see DRAWINGS and a PHOTO of what I mean on my Flash to Bang page.

There is also what is called "dry lightning." That is when lightning strikes from a cloud that is not making rain. Dry lightning often causes forest fires because there is no rain to stop a fire from spreading.

NOTE: When you follow the links on this page to other pages or web sites, you can return to the exact place that you left from on this page by clicking on your browser's back arrow. Also, if you came to my web site by following a link from another web site, your browser's back arrow can return you to that site. If your back arrow doesn't work, you may be trapped in a frame. In that case, try clicking here.

Global Atmospherics is a company that detects lightning and has a computer map that can show each spot in the United States where lightning struck today. This kind of map helps airplane pilots stay away from thunder storms. Their web site has information about lightning science and safety at http://www.glatmos.com/lightinfo/lightinfo.html. To find some really cool lightning maps, go to http://www.lightningstorm.com. Lightning strikes many parts of the world. Check in your country to see if lightning maps are available.

HOW CAN YOU TELL HOW FAR AWAY A STORM IS?

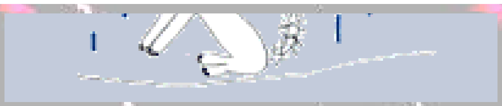
You can tell how far away lightning struck by counting seconds between the flash and the thunder. Every 5 seconds equals one mile, so if you count 10 seconds until you hear the thunder, the lightning flash was 2 miles away. This is shown on my Flash to Bang page.

Can you ever tell when lightning may be about to strike?

Sometimes you can feel when lightning might be about to strike. Try holding your arm very close to the front of a color TV screen that is turned on and see how it feels. Look at the hair standing up on your arm. If you are in or near a storm and you feel this way, then you know that you may be in danger. Lightning could strike any second.

Use the lightning safety links below to learn what to do if this

happens. They tell about shelters and the "lightning crouch" which was formerly called the "lightning safety position." Also, see my Lightning Crouch page.



WHEN YOU ARE CAUGHT IN A STORM, WHAT CAN YOU DO?

Please click on the lightning safety links below to find answers to this question.

WHAT KINDS OF SHELTERS ARE THERE?

Houses, buildings and cars (not convertibles) can give shelter. Please read the lightning safety links for details.

LIGHTNING SAFETY AT HOME.

What's cool about a thunderstorm when you are at home? If someone says that it is "bath time" or "time to do the dishes," you can say "No way! Its not safe!" You should stay away from windows, water faucets, pipes and electrical outlets.

What's not cool about a thunder storm is that if you are talking to your best friend on the phone and lightning is close by, you have to say to your friend: "I'm sorry, but I have to hang up now because lightning is close by."

When there is a storm, do not answer the phone because people can be struck by lightning through the phone. Electricity can go from the phone through your ear and into your brain. Many people (kids too) have been injured while talking on the phone during storms.

If you are playing outside and lightning strikes near by, you should go into a house, a building or a car (convertables are not safe). If you are in a car, be sure that the windows are rolled up. If you can count 20 seconds or less between the lightning and the thunder, the lightning was 4 miles away and the storm is close enough to hurt you. Remember that lightning can strike 10 miles away from a storm. You should decide with your parents how close to a storm is too close for you to be without shelter. Read the lightning safety links about this.

Swimming is not cool when there is a thunder storm around.

LIGHTNING SAFETY AT SCHOOL.

Sometimes, kids have special lightning safety problems because they can't always make their own safety choices. Lightning injuries don't happen very often so many people don't think of lightning as a real danger.

If you are on a sport team and there is a thunderstorm during a game or a practice, what should you do? Should you tell your coach or the person in charge, that the team should get off the field? If the coach says its just a little rain or thunder and not to worry about it, should you leave anyway and take shelter? This is a serious question. You could get kicked

off the team if you leave, but your life is more important than the game. In 1998, a whole soccer team (with 11 players) was killed by lightning in Congo and in 1999, a whole football team was injured by lightning in Colorado. My advice is to talk about this question with your parents and with your coach and team, *before* the season begins. You can also share the lightning scientists' links on this page with your school so they can find professional advice.

I received an e-mail from the mother of a girl who was very badly injured by lightning just after she got off the school bus during a thunderstorm. Should the driver have kept her on the bus until the storm was over? I think that this is a question that parents and schools should talk about too.

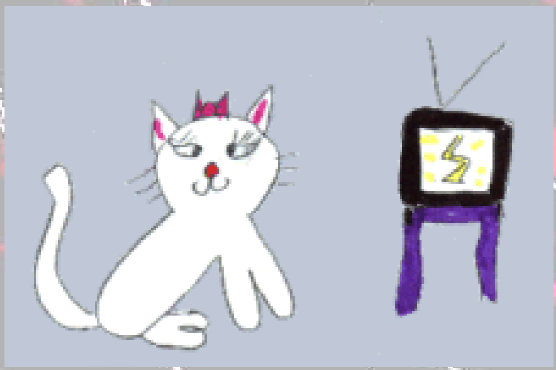
IF THUNDERSTORMS SCARE YOU (they do me):

It is ok to be scared of lightning and thunder because lightning is very dangerous and thunder makes a big noise which is very scary, at least it is to me.

Once you are in a safe place, you can take your mind off the storm by playing games, singing songs, telling stories, reading books, or (my mom says) doing your homework. My friend Deanna and I like to think of angels bowling and their strikes causing thunder. This is a good time to practice math by counting seconds between flashes and booms or crackles to guess how far away the storm is. Lightning crackles are very close and very scary to me.

I've seen some neat TV shows about lightning, tornadoes and hurricanes.

- ***Savage Skies* on PBS**
- **Nova's *Lightning* on PBS**



I like PBS. I ask my friends to ask their parents to help PBS and to write to their Congressmen about it.

Libraries have lots of books about lightning and storms. These are some books that I like:

Weather **by Howard E. Smith, Jr. and Illustrated by Jeffrey K. Bedrick. Doubleday, New York. 1990. It is about different kinds of storms like tornadoes, hurricanes, lightning and hail and has really great drawings of them.**

Flash, Crash, Rumble and Roll **by Franklyn M. Branley with pictures by Barbara and Ed Emberley - Thomas Y. Crowell, New York 1985. It tells a lot about weather and how it works in a way that kids can understand.**

.

Links to other lightning sites on the web.

Some of these links have neat stuff for kids and some are for you to read with your parents.

LIGHTNING SAFETY INFORMATION

For up to date information by lightning scientists, see the
Recomendations by the Lightning Safety Group,
American Meteorological Society Conference in Phoenix, Arizona.
This is a great place to find professional answers to many lightning safety questions.
I think schools should read and use this. You can also find it on web sites by Dr. Cooper, National Severe Storms Laboratory, Global Atmospherics, and others.

The National Weather Service lightning safety site is a good lightning safety reference site.

National Lightning Safety Institute (NLSI) Homepage (http://www.lightningsafety.com/). This site tells about safety for people, buildings, and other interesting things. It also has a section on Personal Lightning Safety Tips. I think that you should read this with your parents and share it with your teachers and your friends. Also, look at: http://www.lightningsafety.com/nlsi_pls.html

Chuck Doswell at the National Severe Storms Laboratory in Norman, Oklahoma gives advice about lightning safety and camping: http://www.cimms.ou.edu/~doswell/tstm_camping_safety.html

Lightning Safety Rules from the Oahu Civil Defense Agency.

People all over the world have to think about lightning safety. This link goes to Zambia in Africa and tells about lightning and computer safety.

Lightning Telephone Danger report from Australia.

USA Today has a lightning information index at: http://206.251.19.76/weather/wlightn0.htm

OTHER LIGHTNING AND STORM INFORMATION

Ron Holle is a meteorologist, formerly with the National Severe Storms Laboratory. He is currently with Vaisala (formerly Global Atmospherics) which does real time tracking of

lightning www.vaisala.com andwww.lightningstorm.com. Ron is an expert on lightning and lightning awareness. He helps me make sure that the information on my web page is correct. The Franklin Institute and the Theatre of Electricity have interesting lightning pages and links. The Franklin Institute pages show different kinds of lightning and tell about what causes it.

If you can, go see The Powers of Nature exhibit. It opened at the Franklin Institute in Philadelphia in 1998 and is traveling around the country. I saw it in Philadelphia and it is really cool. You can learn about thunderstorms, hurricanes, tornadoes, earthquakes, volcanos and real storm chasers. Other museums on the Powers of Nature schedule are: Los Angeles, California Museum of Science - October, 1998; Columbus, OH, COSI - April, 1999; Ft. Worth, Museum of Science & History - October, 1999; St. Paul, Museum of Science - April, 2000; Boston, Museum of Science - October, 2000; Chicago, Museum of Science & Industry - April 2001; and then back to the Franklin Institute - October, 2001.

Check out FEMA's (Federal Emergency Management Agency) Disaster Connection: Kids to Kids for disaster related stories by other kids. FEMA's site has a lot of useful information about all kinds of disasters. [www.fema.gov/kids/k2k_sch1.htm] Vaisala (formerly Global Atmospherics) knows when lightning hits anywhere in the United States. Their web site has some free stuff and links to other lightning sites. Lynne Shumaker, who works there, showed me the things that they work on and helped me to understand more about lightning. You can see a lightning map at www.lightningstorm.com

Scientists at New Mexico Tech do a different kind of lightning mapping, in 3D.
It is sort of like they can "look" at a storm from above and from two sides: http://ibis.nmt.edu/nmt_lms/index.html. They can put maps together and make movies. To see a moving tornado storm, look at: http://ibis.nmt.edu/nmt_lms/tornado.html. It takes almost forever to download, but then it's really fun to watch. NASA's Lightning Primer and Lightning Detection from Space. If you have homework about lightning, this is a good place to start. It tells about what lightning is, history, space and lots of other things.

The National Weather Service in Melbourne, Florida (Lightning Information Center) has great lightning pages. http://www.srh.noaa.gov/mlb/ltgcenter/ltgmain.html

A short Explanation of Lightning by the Oahu Civil Defense Agency.

My dad thinks that Red Sprites and Blue Jets are cool (he says mysterious because very little is known about them). People study them at the University of Alaska, New Mexico Tech, Stanford University (where my friend Emily's dad works) and other places. We first heard about them on PBS Nova. These links tell about red sprites, elves and blue jets and they have photo and movie links for them:
New Mexico Tech (photos and movies) - http://ibis.nmt.edu/sprites/sprites.html;
a good red sprite photo - http://www.sai.msu.su/apod/ap951111.html;
FMA Research on red sprites - (photo and links) - http://www.FMA-Research.com/;
Stanford University (research links) - http://www-star.stanford.edu/~vlf/.
An amateur astronomer in Arizona took pictures of red sprites with his video camera: http://shutter.vet.ohio-state.edu/astronomy/sprites/index.htm.

If you are interested in lightning, red sprites, elves, storms and tornados, then you might also be interested in other planets, stars and galaxies. Scientists at Project SETI (at the University of California) are using a giant radio telescope to search the universe for radio

signals produced by intelligent life in other parts of the cosmos. One problem is that the job is so big that they need help with processing the data. Did you know that you can help Project SETI with your home and school computers? This might make a great science project. The Project SETI@home web site will tell you all about this and let you sign up to help look for ET and other space aliens, if you want to. You can find it at http://setiathome.ssl.berkeley.edu and I've put a link to SETI@home at the bottom of this web page.

COOL LIGHTNING PICTURES AND WEATHER INFORMATION

Chuck Doswell has a page about <"http://www.cimms.ou.edu/~doswell/ltgph.html"> Lightning Photography. He let me use one of his pictures for the the background on this page. He also tells how to take lightning pictures.

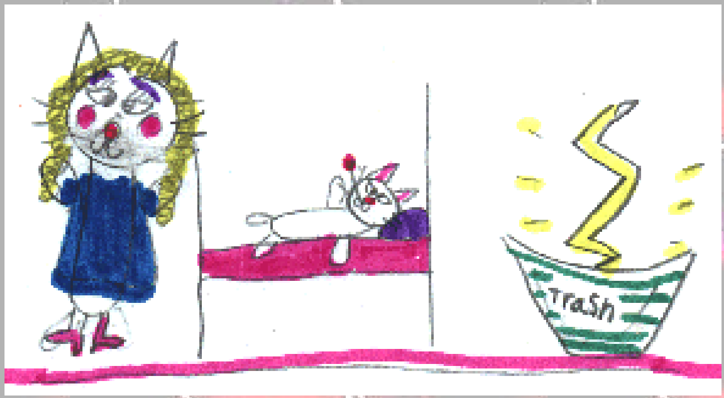
Daniel Robinson's Lightning Page has pictures, experiments, links to maps and lots of other stuff (http://wvlightning.com/gallery.html).

On Nova, I saw people shooting rockets into the sky to cause lightning. James Mathis' pages show Triggered Lightning and other lightning photos.

The Lighthouse page has Satellite and Radar picture maps for many parts of the world. You can see where the big storms are happening.

You can find links to web sites about weather and many other subjects for students and teachers at Studyweb (http://www.studyweb.com).

PEOPLE WHO CAN HELP YOU IF YOU HAVE BEEN HIT BY LIGHTNING



Mary Ann Cooper, M.D. is at the University of Illinois at Chicago and does medical treatment for people who have been hit by lightning. She has been helping me to not be so scared of loud thunder. Her homepage has many lightning medical and safety links and is a very good place to find information about lightning.

Margaret Primeau, Ph.D. does psychotherapy for people who are very scared of lightning because they were hit by it. She is at the Loyola University Medical Center, Department of Psychiatry. Her phone number is 708/216-3272 and her fax number is: 708/216-5885.

Lightning Strike and Electrical Shock Victims, International
c/o Steve Marshburn, Sr.
214 Canterbury Road
Jacksonville, NC 28540-5307
Telephone and Fax Number: (910) 346-4708

These people have all been hit by lightning or had bad electric shocks. Some people are hurt very badly. The people in this group try to help each other.

I would like to get e-mail from other kids who have been hit by lightning. Also, please write to me about other lightning links, books and TV programs that should go on this web page.

My e-mail address is information@kidslightning.info. Please forgive me if I'm not always able to answer, but it's hard for me to keep up with the letters plus my homework and music practice.

Thank you for visiting my web site. Please come again because I'm always adding new things about lightning. Please let me know if you find any links or URLs to other sites on this page that do not work.

SPECIAL THANKS

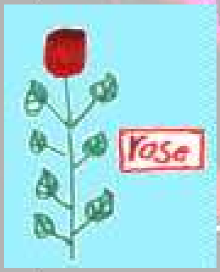
Thank you to Dr. Mary Ann Cooper of the University of Illinois Hospital, Lynne Shumaker of Global Atmospherics, Ron Holle, Chuck Doswell and Raul Lopez of the National Severe Storms Laboratory, Ken Howard and Al Moller of the National Oceanic and Atmospheric Administration, and Dr. Margaret Primeau at the Chicago Medical School. They have helped me learn about lightning and let me use information, links, maps and pictures. Mark Taylor helped with programming questions and animation. And thank you Elizabeth Anne, Ashlie and Georgiana for letting me use your stories.

I am grateful to María Cristina and her family from Bogata who are translating parts of my web site into Spanish and to Kim and Joas from Kenya and Tanzania, who are translating my web site into Kiswahili. My thanks also go to Dr. Elisabeth Gourbière for helping to translate this web site into French so French speaking children will also be able to learn about lightning safety. She lives in France and does research on lightning injury and safety.

Thanks also to the many people who have sent me link updates, comments and suggestions for this web site.

DEDICATION

This web site is dedicated in memory of my aunt Rosemary and also to my grandmother and grandfather who are very special to me.



SOME NON-LIGHTNING THINGS

- Keep your computer virus safe. -
Update and run your antivirus program at least once a week.
Also, use a firewall.

Project SETI@home

You can help scientists listen for ET (extra terrestrials or space aliens).
"SETI" means Search for Extraterrestrial Intelligence.
Click on this link to learn all about SETI@home. It is fun and free.

Remember that you can use your browser back arrow to return to my lightning safety page again.

If you or your class want to learn about ancient Egypt or African wildlife in Zambia and Zimbabwe, these links will take you to information about videos of these countries.

You have probably guessed that cats are my favorite animal. Here is a link to a neat web page with really cute cat animations (they have one about dogs too). It is all about cats and how to get to know them and take care of them. This site is run by volunteers who have a pet shelter and adoption service. They keep animals until homes are found for them. http://www.azstarnet.com/public/nonprofit/fair/catwise.htm

Back to my lightning introduction page.

anubisbastet@earthlink.net

Updated 4 June 2004

Links to Awarding Organizations

Browser Upgrade Links
It is best to look at this site with a browser at least as new as Netscape 2.

I like the new Firefox browser, and it is free.

Get Firefox

SEARCH OR TRANSLATE

If you didn't find the lightning information that you need,
you can search my kidslightning info site with Google,
or you can use it to search for other lightning web sites.

You can use the AltaVista links (select a flag)
for approximate computer translations of this web site.

[Please note that I don't endorse any advertisements that may come up on Google or AltaVista.]

Google Search

WWW kidslightning.info

For approximate computer translations to other languages:

Lightning & Atmospheric Electricity Research at the GHCC

NOTICE: Version 4.1 of LIS data is now available. More information.

Within the Global Hydrology and Climate Center (GHCC), there is a group of researchers, mostly scientists and engineers, who collectively form the GHCC Lightning Team. As part of their research activities, the members of this team have been investigating the causes and effects of lightning as well as analyzing a wide variety of atmospheric measurements related to thunderstorms.

One of the primary objectives of this group is to determine the relationship between the electrical characteristics of storms and precipitation, convection, and severe weather. In order to achieve this objective, the GHCC Lightning Team has designed, constructed and deployed numerous types of ground based, airborne, and space based sensors used to detect lightning and characterize the electrical behavior of thunderstorms. The data collected by the GHCC Lightning Team is routinely shared with scientists around the globe, resulting in numerous advancements in the field of Atmospheric Science.

Global Lightning Image

A Lightning Primer

A historical essay on lightning research. This primer describes the characteristics of lightning and provides information on recent activities in lightning research.

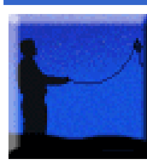
Dataset Information

Access to data from the Lightning Team's experiments, information about the data, and links to other sources of lightning data.

Space Research & Observations

*Learn about **LIS**, **OTD**, **LMS**, and other space based lightning detection instruments designed, built, and maintained by the Lightning Team.*

Field Campaigns & Ground Validation



An overview of field programs in which the Lightning Team has participated, including a description of some of the instruments that were used.

File Cabinet & Bookshelf

Documents, reports, press releases, and an assortment of other information related to our research activities.

NASA Contact: Steve Goodman, Ph.D.
Site Curator: Danny Hardin

Weather News | Storm Gallery | Video Center | Storm Chasing | Lightning Library | Story Archive

Features

2003 Weather Highlight Video

I-64 Accident Caught on Video

A lightning bolt near Frametown in Braxton County on Sunday. [Full Story]

Tough times? Let us pray for you.

sign up for wvlightning.com weather alerts!

wvlightning.com storm tracking vehicle

Latest Observations: Haze
Temp: 78°F - *Wind*: Southwest at 5MPH
in Charleston, WV 11:52AM Friday 8/27/04

Learn & Explore

Lightning Library
How Lightning Works
Trees | Power Lines | Safety
Vocabulary | Strike Survivors
Thunder | Sferics | Types
Static Electricity | Ball Lightning
Protection Systems | The Bible
FAQ | Myths | Books | More . . .

Multimedia
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Storm Chasing
FAQ | WV Severe Weather
Photo Guide | Tornado Alley
Storm Chaser Database
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The Message

Salvation in Jesus Christ
Find out how to be forgiven of your sins and change your eternity.

Christians: Myths & Facts
An informative page devoted to common modern-day myths about Christians.

Why Jesus?
Hear the rest of the story about following Christ and the passion of those who follow Him.

Evidence
Evidence for God? You bet.

Small Graces
Sometimes the Lord does something in my life that's so cool, I just have to stop and write it down.

Site Extras

Also on wvlightning.com
Pass the Test
Appalachian Skies
Weather Video Archive
The Samurai
Eternal Security

wvlightning.com web hosting is provided by CIS Internet™, West Virginia's family-friendly Internet service, providing quality filtered dialup and high-speed access.

Top Story

August 29, 2004 - *Active Weather Alert*

Stormy Saturday night

FRAMETOWN, WV - The skies along the Interstate 79 corridor were dominated by explosive thunderstorms overnight into Sunday morning. Most of the state experienced multiple thunderstorms during the overnight hours - and with brilliant, loud and close lightning, strong winds and torrential downpours, staying asleep wasn't easy. *Left: Lightning along I-79 on Sunday morning.*
[Full Story]

CHASE VIDEO: Frequent, close and bright lightning in central WV: RealVideo, 6.8MB

WEATHER LINKS: Severe Weather Outlooks | More Local Weather Links

Recent Headlines

[Full Archive]

On TV: **August 10: Severe storms pound state**

CHARLESTON, WV - Severe thunderstorms charged across the state on August 10, with large hail, strong winds, heavy rain and frequent lightning. Hail up to the size of quarters was reported in many locations. Street flooding was also a problem as heavy rains inundated the area. *Right: Lightning lights up the sky in Dunbar, WV in one of several strong storms to affect the area on August 10.*
[Full Story]

On TV: **July 29: Fog brings low visibilites**

CHARLESTON, WV - Dense fog was widespread across parts of the state on Thursday morning. While the warm rivers kept valleys somewhat clear, driving anywhere else was tricky due to the reduced visibilites. At Yeager Airport, planes taking off were completely obscured from view. *Left: Dense fog hangs over Charleston, from wvlightning.com video on **The Weather Channel** on July 29.*
[Full Story]

On TV: **July 25: Sunday evening downpours**

HUNTINGTON, WV - After a quiet Sunday afternoon, storms rolled into the Charleston-Huntington metro areas after dark. Heavy rain and lightning arrived first in Huntington around 11PM, and later in the Charleston area after midnight. The storms are the first sign of an active weather pattern that will affect the area again on Monday. *Right: Lightning explodes in the sky over the Cabell County courthouse in Huntington, from wvlightning.com video on **The Weather Channel** on July 25.*
[Full Story]

On TV: **July 22: Summer storms make a comeback**

SOUTH CHARLESTON, WV - After an over two-week period of mostly dry weather, two rounds of storms and heavy rain affected the Mountain State on Thursday. The first batch of storms lasted much of the afternoon and brought up to 2 inches of rain to parts of the region. Minor flooding was reported in several locations. Later in the evening, a second round of storms with a display of frequent lightning affected western and southern parts of the state. *Right: Lightning fills the sky above Route 119 near Alum Creek, south of Charleston.*
[Full Story]

CHASE VIDEO: Lightning along Corridor G: RealVideo, 1.2MB

On TV: WOWK-TV Channel 13 ran a story on wvlightning.com on Wednesday, July 14 during the 11 o'clock news. If you missed it, you can view the video online, courtesy of WOWK-TV. A big thanks to Spencer Adkins and Channel 13 for running the story!

Video Archive

GO

wvlightning.com Severe Weather

wvlightning.com On TV

wvlightning.com video of current and past weather events is used regularly on national and international television broadcasts. Below is a list of our most recent video appearances:

August 27, 2004 - **The Weather Channel**
Morning rain in Charleston, WV.

August 23, 2004 - **The Weather Channel**
Foggy sunrise in Charleston, WV. [Story]

August 10, 2004 - **The Weather Channel**
Severe storms and hail in Charleston, WV. [Story]

August 5, 2004 - **The Weather Channel**
Morning rain in Charleston, WV. [Story]

July 29, 2004 - **The Weather Channel**
Morning fog in Charleston, WV. [Story]

July 25, 2004 - **The Weather Channel**
Thunderstorms in Huntington, WV. [Story]

July 22, 2004 - **The Weather Channel**
Heavy rain in Charleston, WV. [Story]

July 10, 2004 - **The Weather Channel**
Flash flooding in Kanawha County, WV. [Story]

June 15, 2004 - **The Weather Channel**
Flooding in Dunbar, WV.

June 4, 2004 - **The Weather Channel**
Midday rain in Charleston, WV. [Story]

[Full On-Air Log]

wvlightning.com/Appalachian Skies Media licenses video content to production and broadcast media clients. We offer up-to-date video of current weather events as well as a stock video archive of various weather phenomena. For more information, please visit appalachianskies.com or call 304-610-1374.

Disclaimer: wvlightning.com provides video content to media outlets as a private contractor. This site is not supported, sponsored, endorsed, or otherwise affiliated with any of the media outlets that broadcast wvlightning.com material.

WOWK-TV NEWS CLIP: RealVideo, 9MB
LINK: WOWK-TV web site

So who are these 'storm chasers'?

So what's with the storm chasers? Are they high-risk adrenaline junkies? Is the hobby of chasing tornadoes a dangerous 'extreme sport'? What about all these newspaper articles that say chasers are 'tornado tourists' that block roads, celebrate destruction, and cause havoc in storm-ravaged towns? We're bringing you 'the rest of the story': Most storm chasers are responsible, safety-oriented and helping keep communites safe during severe weather. Read about what storm chasing, and the people who make up the hobby, are really like in our Storm Chasing FAQ.
[Full Story]

FAQ: Storm Chasing FAQ
PROFILES: Meet storm chasers from around the world in the Storm Chaser Database

On TV: **July 10: Saturday storms blanket state**

LIBERTY, WV - Thunderstorms covered West Virginia on Saturday, affecting almost every county in the Mountain State. Many locations, such as Kanawha and Putnam Counties, endured two or three storms before the day was over. Flash flooding was reported in various locations across Kentucky, Ohio and West Virginia. *Right: A truck drives through floodwaters on Allens Fork Road on Saturday, from wvlightning.com video on **The Weather Channel** on July 10.* [Full Story]

2004: Year of the photogenic tornado

GREAT PLAINS USA - Most storm chasers regard the 2004 Plains storm season, which peaked in late May and came to a close last month, as one of the best ever for breathtaking, picture-perfect tornadoes over the open prairies. Our trip to Tornado Alley this year yielded an incredible twelve tornado intercepts in four states. Come along for the ride with our 2004 season recap, a daily chase logbook with photographs and video documenting four weeks of following the big storms on the open Plains.
[Chase logbook, photos and video]

July 6: Storms rumble across Appalachia

CHARLESTON, WV - Lightning and thunder kept many residents of Kentucky and West Virginia awake on Tuesday night. More thunderstorms, some possibly severe, may affect the same locations on Wednesday.
[Full Story and More Photos]

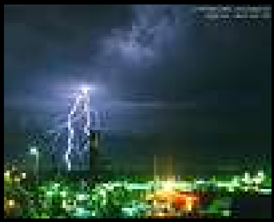
WEATHER NEWS STORY ARCHIVES:
Past weather news stories from the wvlightning.com front page are archived back to January of 2003:

2004 story archive - From January 2004 to present.
2003 story archive - Last year's headlines.

Lightning Photography *Page 1*

Dave 'Stormguy' Crowley

Click thumbnails for larger images *Pages* 1 2 3 4 5 6 7 8 9 10





















National Lightning Safety Institute

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1 About NLSI

2 NLSI Business Services

3 Lightning Incidents

4 Personal Lightning Safety

5 Structural Lightning Safety

6 Reference Information

Of More General Interest:

1.	Fun With Lightning - For students of all ages
2.	Vehicles and Lightning - Safety recommendations for vehicles and photos of a Jeep struck by lightning
3.	When Lightning Strikes People - A NASA report on what happens when people and lightning interact
4.	Colorado Lightning Resource Center - Resources from the National Weather Service
5.	Lightning Protection: New Myths & Old Realities - Submit this letter to the editor of your local newspaper
6.	Make Very Tiny Lightning - An Exploratorium experiment
7.	Lightning Strike Probabilities

4
Personal Lightning Safety

4.1 Decision Tree for Personal Lightning Safety
NEW Added 7/21/03

4.2 Multi-Agency Recommendations for Lightning Safety - Consensus of the Lightning Safety Group American Meteorological Society Conference Phoenix, Arizona, 1998

4.3 Information for Lightning Strike Victims

4.4 Lightning Safety Tips

4.5 Lightning Safety in NLSI's Home Town (Louisville, CO)

- 4.5.1 Louisville Ballfields
- 4.5.2 Louisville Parks
- 4.5.3 Louisville Pools

4.6 Lightning Safety for Organized Outdoor Athletic Events

4.7 Indoor/Outdoor Swimming Pool Safety

- 4.7.1 Lightning and Aquatics Safety: A Cautionary Perspective for Indoor Pools

4.8 Lightning Safety for Campers and Hikers

4.9 Boating Lightning Safety
4.9.1 Boating Lightning Protection - Information from the University of Florida

4.10 Lightning Safety for Outdoor Workers
NEW Updated 5/4/04

4.11 Lightning: The Underated Weather Hazard - By William P. Roeder

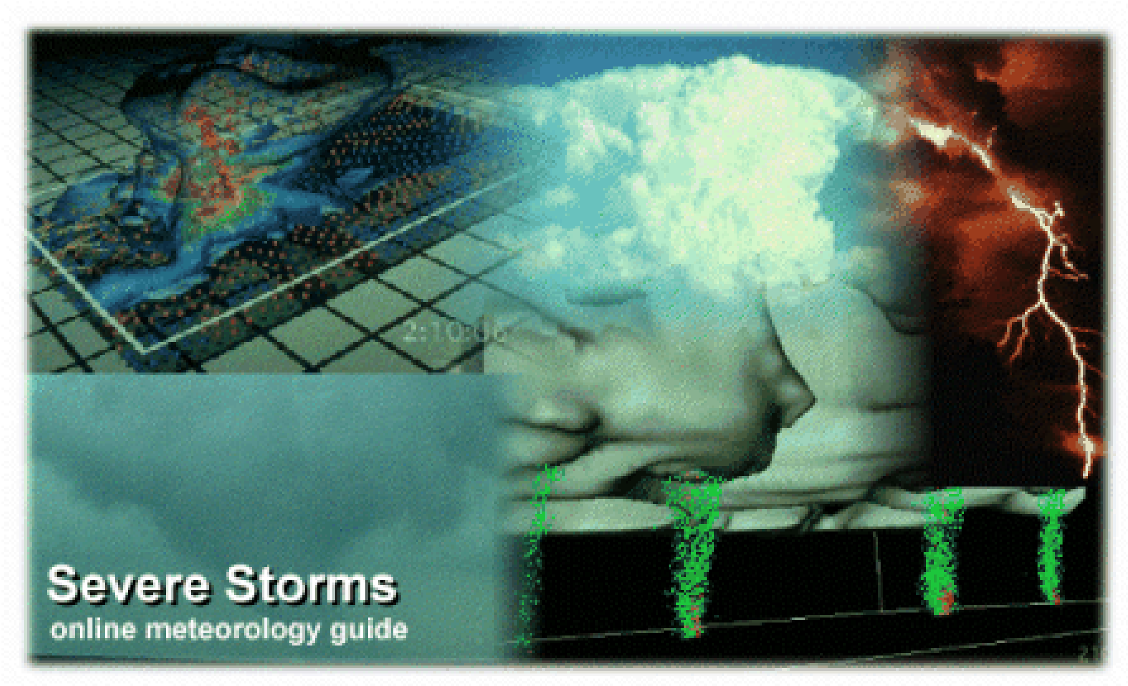
4.12 NCAA Sports Medicine Handbook Lightning Safety Guideline - This document is mandatory for all colleges and universities in the USA. Shouldn't your recreation and sports organization be in compliance? (PDF)

4.13 A Lightning Safety Mandate For The Game Of Golf

4.14 US Golf Association Lightning Warning Information

Note: You may need to download the newest Acrobat Reader to view some PDF files on this site.

National Lightning Safety Institute
Providing expert training and consulting for lightning problems



Graphic developed by: Dan Bramer

The Severe Storms Module is a combination of two elements. The first is the NOAA Severe Storms Spotters Guide. The second is a section recently added to discuss the efforts and results of modeling severe storms. The Severe Storms Spotters Guide contains supplemental instructional resources and a program designed to familiarize meteorologists and advanced severe storm spotters with the basic "building blocks" of convective storm structure. The focus of the training series is the development of a thunderstorm "spectrum" and a discussion of the physical characteristics and severe weather potential of the various storm types in the spectrum.

Sections

Last Update:05/15/99

Dangers of Thunderstorms
Includes: lightning, floods, hail, winds and tornadoes.

Types of Thunderstorms
Single cells, multicell clusters, multicell lines (squall lines) and supercells.

Components of Thunderstorms
Updrafts and downdrafts, outflow phenomena, wall clouds and the effects of wind shear on thunderstorm development.

Tornadoes
Tornadoes, cyclic storms and low-level flow fields associated with tornadic thunderstorms.

Modeling
Supercells, squall lines, and other phenomena recreated inside computers for the benefit of forecasting and understanding.

Acknowledgments
Those who contributed to the development of this module.

The critical role of atmospheric dynamics and thermodynamics in determination of storm type is stressed. We will take a close look at the storms themselves; from the small, summer storms capable of producing dangerous "microbursts" to the large "supercell" storms which spawn destructive tornadoes.

The navigation menu (left) for this module is called "Severe Storms" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Upper Air Features

Dangers of T-storms

Sparks and Lightning

(C)1996 William Beaty

While attempting to explain sparks and lightning to some friends, I realized that I didn't have a good gut-level understanding of them myself. As usual, my lack of understanding was an attractive irritant, like a pimple that one can't help picking at. And so over many months I kept noticing concepts that could be applied to explanations of sparks. Here's what I've come up with.

To get a good understanding of sparks, you need to encounter their behavior in detail. One way to do this would be to magnify a small spark, but sparks happen so quickly that interesting behavior can't be seen, so in addition to magnifying it, we'd have to slow it down somehow. Here's a better idea: speed yourself up instead. Imagine that you've been exposed to Tholosian water from 'Old Trek.' This is the substance which causes you to live many times faster than normal. (TV-show science fiction trivia experts will recall the appearance of a similar drug on The Wild Wild West as well!) And then, instead of magnifying a tiny spark, let's go outside during a storm and look at the behavior of an already-large spark. Except for its size, the strange behavior of lightning is very similar to the behavior of tiny sparks.

So, we're standing outside in the time-frozen world of a raging thunderstorm viewed from our 1000X perceptual acceleration. The trees and bushes around us are thrashing frozenly in the stopped wind, and a few torn shingles flying from the nearby roof hang in the air nearby. Higher up we see a tangled, branching network of dimly glowing wiggly purple lines which look something like a tree root. And like a root, all the tips of the branches are lengthening. But this can't be lightning, it's dim and purple, not bright blue-white.

One branch-tip is about a hundred feet up from where we're standing. We can see that the wiggly line isn't moving, it's only growing at its tip. It takes a tortuous, kinky path as it lengthens, and occasionally a new branch starts growing from the side of the main one at a spot where there is a particularly sharp bend. Then we notice something else: everything on the ground is starting to glow. Bits of dim purple fire are popping into existence on the tops of bushes, the edges of the roof of the nearby house, the tips of the rooftop TV antenna, on the ends of all the tree branches, and even on the flying pieces of roof shingles. As the exploring finger of dim purple lightning comes downward, the purple "fire" on all the objects becomes more and more intense. If you hold your hand in front of you, the tips of all your fingers spout dim purple fire as well.

Now the dim purple lightning from above is about thirty feet away, and the downward growth of its tip seems to be speeding up. Then something really disturbing happens. One of the purple flames coming from your fingers has suddenly started growing upward as a narrow wiggly violet line! You pull your hand down, but it's too late, the streamer of purple stays attached and grows upward fast, it's two feet long by now. You notice that this purple streamer from your hand isn't the only one, there are now jagged purple lines growing upwards from many places which formerly had the little "St. Elmo's Fire" flames. There's a ten foot streamer coming from the tree, another from the bush, and a couple from the roof of the house and the TV antenna. They appear to be moving towards the incoming lightning strike. There are even several coming from the wind-blown shingles, but some of these are extending downwards towards the ground while others grow upwards. The one from you're hand isn't winning, it apparently had a late start, and the streamers coming from the tree and the shingles are really shooting upwards now ahead of all the others. And the downwards-growing streamer from the shingles has touched the ground and is spreading out into a small disk of purple rootlets on the surface of the ground.

Finally the upward-growing streamer from the shingles approaches the lightning streamer coming from above. The two growing branch-tips race together, and just before they meet they split into several separate branches which all connect. And NOW it suddenly looks like lightning, because the entire streamer from the shingles is glowing brighter and brighter. The little disk of purple filaments where it touches the ground is now several feet across and looks like blazing blue-white tree roots. The whole thing is far too bright to look at, and it's getting brighter still. And something is happening to you. Your fingers hurt, the muscles in your arm are tensing by themselves, and you feel yourself blacking out. As you lose consciousness, you note that the short, dead-end streamer from your hand is still jutting upwards into the air, glowing bright blue, though nowhere near as brightly as the streamer from the shingles.

What the heck was all that?! Lightning struck an object hanging in the air?! Well, sort of, since the shingles somehow launched their own lightning. And how could lightning be coming from objects on the ground, and from your hand? Why were you knocked unconscious even though you didn't get struck directly by the main bolt? And isn't lightning supposed to travel at the speed of light? 1000 times speedup is nothing compared to lightspeed, so why did we see the lightning as a bunch of slowly-growing filaments?

There are some mental tricks you can use to understand some of what went on above. Number one: realize that lightning is not made of electricity. "Lightning is electricity" is a false concept which stands in your way of understanding, and you need to get rid of it before you can figure out what's going on. The long purple filaments which extended through the air are not electricity, they are actually made of air. They are nitrogen and oxygen which has been converted into plasma. Plasma is vaguely like fire, but it is not necessarily hot. When air is converted to plasma, the electrons of the gas atoms are knocked off the atoms and become able to flow along through the air. Plasma is a conductor, so it's not too wrong to think of purple plasma filaments as being like wires made of conductive air.

Another mental trick: when you take a conductive object, a metal bar for example, and hold it in a strong electric field, flame-like "St. Elmo's Fire" sprouts from the ends of the bar. The "fire" is nitrogen/oxygen plasma. And plasma itself IS a conductive object. So, if an electric field is strong enough, and if a tiny bit of air is somehow converted into plasma, it's as if your conductive rod has grown little conductive pieces on its ends. And next, the "sharp" parts of the plasma globs will themselves sprout extra bits of plasma. And so your metal rod has started "lengthening itself" via fingers of air-plasma. The air can "catch fire" with an outbreak of plasma which grows and grows, with more air turning to plasma as the rods of plasma grow more plasma on their tips.

The plasma takes a particular form: long thin twisty rods. This occurs because "St. Elmo's Fire" always starts on the sharpest part of an object, and the sharpest part of a rod is the end of the rod. And so a pre- existing rod of plasma will grow more plasma on its tips and lengthen itself. This self-forming plasma conductor is vaguely like a motorized metal antenna on a car which extends upwards. But the plasma-antenna can lengthen itself continuously as long as it's tip is still in a strong electrostatic field.

If the twisted plasma rod should make a sharp bend as it grows, the bend can behave as a sharp point and more plasma fingers can take off from the bend. In this way a lengthening plasma streamer develops branches as it goes. Growing plasma doesn't just form twisted rods, it often forms trees, it forms entire complicated systems of rootlets which advance and spread. Whether it forms trees or straight unbent paths depends on the shape of the e-field. in the space around it. A parallel e-field will allow tree-shapes to grow. A spreading, radial-shaped field will tend to force one plasma finger to grow faster than all the others, resulting in a needle-straight spark.

Since plasma is a conductor, what do you think would happen if a piece of air-plasma were to connect itself between two highly-charged objects having opposite charge? ZAP! The opposite charges would be shorted out. An enormous electric current would exist for a moment. This is what happens during a lightning strike, or during the tinyest spark. Long filaments of air-plasma within the clouds extend and explore downwards towards the ground and upwards into the charged raindrops. A system of fine plasma-rootlets develops which connects most of the raindrops to the main conductive plasma tree structure. When the conductive plasma touches the ground, it discharges both the charge on itself and the charge on the the huge number of electrically charged raindrops. The large momentary electric current makes the dim purple plasma explode with light and sound.

So, what about lightning and the speed of light? Why can we see lightning "strike" across the clouds, yet light itself moves so fast that we never see moving light beams? Why can we sometimes see sparks jump from object to object? This is because the growing motion of lightning and sparks is actually the growth of plasma filaments. It is not a movement of light. Lightning can "strike" slow or fast depending on how fast the plasma filament tips are extending themselves. In very large Tesla Coil systems, the giant sparks can lengthen VERY slowly, a human can sometimes outrun them.

In the speed-up story at the top of this page, how come there were plasma filaments appearing on the ground and growing upwards? And why did the wind-blown shingles send plasma filaments both up AND down? This is hard to explain without going into detail about electric fields and atoms. But here's a similar question: suppose you squeeze a clod of dirt between your thumb and forefinger until it cracks. Would you expect the crack to start at your thumb, or at your finger? Or might it start from a small spot in the dirt and grow outwards in two directions at once? In truth, applying force to the dirtball can cause a crack to start ANYWHERE within the dirt.

Cracks tend to start at defects, and a similar thing is true with lightning and sparks. An invisible field of electric force, if applied to air, can cause plasma filaments to burst into existence anywhere in the part of the air where the field exists. When lightning is advancing towards the ground, there is a strong electric field all through the air around the plasma branch and in the space above the surface of the earth. This strong field can trigger new plasma filaments to grow anywhere. Of course its main effect is to make the main lightning filament lengthen and grow downwards. But those blowing shingles represented a "defect" in the air, they distort the invisible electrostatic field in the air and strengthened it near the shingles, just as a bubble in stressed glass can distort the mechanical forces and initiate a crack in the glass. The electric field present throughout the air caused two plasma dendrites to take off from the shingle and "strike" simultaneously upwards and downwards. The defect in the air caused the air to "crack" electrically, the crack being made of 3D plasma filaments.

The same thing happens when aircraft fly between oppositely charged parts of a thunderstorm: the plane acts as a triggering defect in the air, and plasma fingers launch themselves from two spots on the airplane. Flying a plane near a thunderstorm is like poking a highly-stressed windowpane with a nail: the cracks start where the nail touches. Yes, that's right, research has shown that aircraft rarely are struck by lightning, instead the aircraft themselves do the striking, since the plasma starts on the wingtips and zips outwards, striking the clouds.

SEE: LIGHTNING WEBRING

Created and maintained by Bill Beaty. Mail me at: billb@eskimo.com.
If you are using Lynx, type "c" to email.

The Closest 12 Stroke Lightning Strike
Ever Caught On Video

SEE MORE VIDEO AT:

Caught-On-Video.com

DaVideoClip
A RealPlayer Video of "The Strike" created by my good friend "LightningChaser" William Coyle.

DaStills
21 of 75 still frames detailing 4 return strokes.

Animated DaGif
Animated Gif file of sizzling action.

As Seen On DaTV
Documentaries, weather shows and promotions that featured The Strike

DaPostcard
Send a Lucky Strike of Luck Postcard and receive incredible luck.

About Me
A brief synopsis of myself.

DaLinks Library
Links to the world of Lightning and severe weather.

DaBanners
Linked banners to great severe weather related pages.

Welcome to
www.DaStrike.com

New! **SEE " THE STRIKE " REALPLAYER VIDEO CLIP**

Download Low Quality FIle: 335KB
Needs RealPlayer to play Download RealPlayer

"The Strike" is an extremely lucky capture that is considered to be the "Closest 12 Stroke Lightning Strike Ever Caught On Video" of which is currently being considered and reviewed by GUINNESS BOOK OF WORLD RECORDS.
I am thankful for this capture, yet I would not recommend that anyone attempt this since it was obviously NOT MY INTENTION TO CAPTURE THIS PHENOMENA at that moment and luckily I was not injured.
Many stormchasers capture beautiful artful expressions of LIGHTNING and other severe weather phenomena, but Professional Stormchasers do it SAFELY.
I would recommend for anyone attempting to capture natures dangerous beauty to first READ ALL SAFETY REQUIREMENTS before attempting to do so.
You can access a vast variety of LIGHTNING PHOTOGRAPHY, EQUIPMENT PAGES and SAFETY RELATED websites in my links page.

Enter DABIO for "The Strike Bio Page" more info and links.

or

Enter DAMENU for direct "The Strike Menu Page" links.

To COUNT My Visitors I Use Site Meter

To TRACK My Visitors
I Use Extreme Tracker As of March 25, 1999

SEE MORE VIDEO AT:

DaGuest Pics
Lightning pics
by professional
storm chasers.

DaNew Pics
A few new lightning
pics I was able to
capture in 1999.

DaBio Page
Brief bio o fThe Strike
and a more detailed
description of the
DaStrike.com website.

DaDamage
Severe damage
caused to the tree,
split right down
the middle.

DaProto Products
Cool DaStrike
creations guaranteed
to strike up anyones day.

DaGuestbook
Sign my guestbook
and tell me your
striking story.

DaMenu Access
Quick menu access
of the whole site.

Add DaLink
Put a link to your
severe weather website
and see the traffic
come through

DaWebrings
Access great sever
weather sites
linked together.

Caught-On-Video.com

Please Sign My Guestbook

View & Sign
My Guestbook

This Lightning Strike site is owned by:
Hernan Cortes

Go to:
Next Site | Skip Next Site
List Next 5 Sites
Previous | Random

Join the Lightning Strike

Strike One

By Michael Fewings

Index

Home Page
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Guestbook
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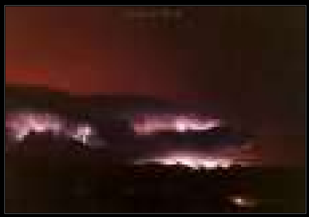
Email

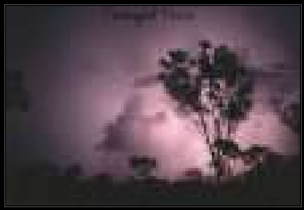
To look at any of the photos in this section, just move the mouse over the appropriate titles and a thumb nail size image should appear

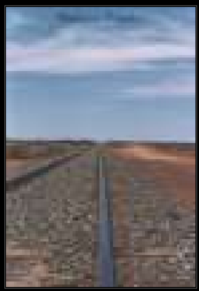
Then follow to see a bigger size

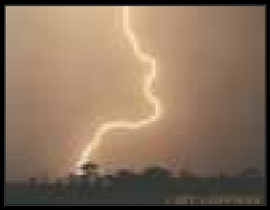
Note: It may take a short while to load all of the images.

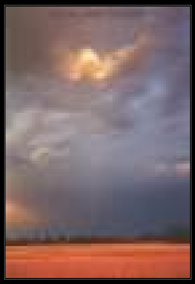
Thor	One in Many	The Road	Fire Fury
S, S & S	Other Side P.1	Other Side P.2	Suburbs
The Hand	Blue Top!	Big Strike	Close
Two For One	Fire Strike	Storm of Dusk	Tranquill Tree
Nowhere Tracks	Rain Central	The Cave	Reaching
Lazy Lightning	Island Storm	Storm and Stubble	Lakeside
Not Quite	Gregs First	Willy Willy	Grey

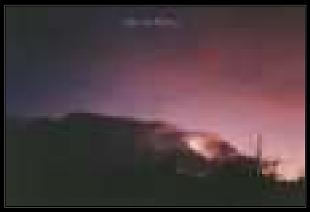




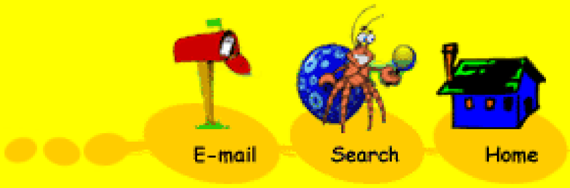








Thunderstorms



[» Disaster from a Kid's Point of View]

[» Professor B's Thunder & Lightning Secrets]

[» Important Terms]

[» Sabrina's Lightning Safety]

[» What is Lightning?]

[» If Someone is Hit by Lightning]

[» Lightning Fact and Fiction]

While thunder won't hurt you - lightning will! So it's important to pay attention when you hear thunder. Thunderstorms happen in every state and every thunderstorm has lightning. Lightning can strike people and buildings and is very dangerous.

Thunderstorms affect small areas when compared with hurricanes and winter storms. The typical thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. Nearly 1,800 thunderstorms are happening at any moment around the world.

Despite their small size, all thunderstorms are dangerous. Every thunderstorm produces lightning, which kills more people each year than tornadoes. Heavy rain from thunderstorms can lead to flash flooding. Strong winds, hail, and tornadoes are also dangers associated with some thunderstorms. You can estimate how many miles away a storm is by counting the number of seconds between the flash of lightning and the clap of thunder. Divide the number of seconds by five to get the distance in miles. The lightning is seen before the thunder is heard because light travels faster than sound. (Of course, get safe shelter first, before you take the time to count the seconds!)

Thunderstorms need three things:

- Moisture - to form clouds and rain.
- Unstable Air - relatively warm air that can rise rapidly.
- Lift - fronts, sea breezes and mountains are capable of lifting air to help form thunderstorms.

Thunderstorms are most likely to occur in the spring and summer months and during the afternoon and evening hours but they can occur year-round and at all hours of the day or night. Along the Gulf Coast and across the southeastern and western states, most thunderstorms occur during the afternoon. Thunderstorms often occur in the late afternoon and at night in the Plains states. Thunder and lightning can sometimes even come with snowstorm! During the blizzard of March 1993, lightning resulted in power outages near Washington, D.C.

FEMA for Kids

Federal Emergency Management Agency

LIGHTNING

INTRODUCTION

Lightning is a powerful part of Earth's weather. A single bolt of lightning is hotter than the sun. And in the time it takes to blink, lightning can strike the ground five times. You can learn about these facts and more when you read through this lesson all about one of the most destructive forces of nature.

Choose from the following pages:

Static Electricity explains why you sometimes get shocked when you touch things, and explores the mysterious connection between static electricity and lightning.

STATIC ELECTRICITY

The Big Spark explains lightning, showing how tiny cloud particles help produce a huge electrical charge.

THE BIG SPARK

Thunder is a section about thunder, naturally. Find out why lightning causes thunder, and how you can use thunder to tell how far you are from the lightning bolt.

THUNDER

The **Safety** section covers lightning safety, from tips on how to avoid being struck to an interactive page where you can choose the best shelter.

SAFETY

Experiments has a bunch of experiments with static electricity, since lightning is too dangerous to experiment with. They're still fun, but they won't fry you.

EXPERIMENTS

The Quiz is a test to challenge your knowledge about lightning and thunder. You can take it online, and get an instant grade.

THE QUIZ

The **Teacher's Guide** is for educators who want an overview of this lesson, the lesson objectives, and more.

TEACHER'S GUIDE

Reduce, Reuse, Recycle Theme Page

Here are a number of links to Internet sites which contain information and/or other links related to the specific theme of Recycling. Please read our disclaimer.

- ## Access Excellence
  - Ecology of the Dump Three activities concerning solid waste management. One lasts one week, another several months, and there is a follow up activity suitble for both.
  - Waste Management There are four activities in this teaching unit in which students investigate household trash, biodegradability, packaging, and recycling.
- ## Ask Eric Lesson Plans - Pollution and Recycling

  This lesson focuses on three types of pollution and how students can work together to cycle..
- ## Composting in Schools

  Menu selections include: Why Composting? Teacher's Page (lesson plans, activities, teacher forum); Ideas for Student Research Projects; Compost Quiz; Science and Engineering (explaining the science and engineering behind composting; includes experiments); Composting Indoors; Composting Outdoors; Weird and Unusual Composting; and, Frequently Asked Questions.
- ## Hazardous Waste Disposal Theme Page

  This CLN theme page has resources for both students and teachers on the topic of hazardous waste disposal. Many of these will provide background information that will be useful to students researching recycling issues.
- ## [The] Imagination Factory

  You'll find creative ways to recycle by engaging your students in art projects/activities that make use of a ready source of inexpensive art supplies - namely your trash. Be sure to look in their "Previous Art Activities" for an archive of their suggestions - organized into 10 categories: Drawing, Sculpture, Painting, Holidays, Printmaking, Fiber Arts, Collage, Marbling, General Information, and Crafts.
- ## Lesson Plans

  Eleven lesson plans in recycling for students in grades 1-7 from the Texas Natural Resource Conservation Commission (TNRCC). In addition, there are three lessons on composting from the Texas A&M University.
- ## Recycle

  Instructions for an educational card game for students aged 8 - 12 in which they become familiarized with the various recyclable items that are normally discarded in the garbage.
- ## Recycling Lesson Plans

Eight lesson plans for students in K-12 from the Pennsylvania Department of Environmental Protection. They illustrate a variety of recycling concepts, including the creation and collection of waste, developing attitudes against littering, recycling as an alternative to disposal, and learning about the costs of disposal.

- [Reduce, Reuse, Recycle]

  The main objective of this teaching unit is to change students' personal behavior through awareness. The lesson plan includes helpful background information, links to resources, student activities, and lecture notes. Grades 1 - 12.

- [RotWeb]

  Everything you wanted to know about composting. Check out their "Teacher Resources" for student handouts, activities, and other resources.

- [Smile Program Biology Index]

  Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has a few lessons on recycling in their section on Environmental Studies and Ecology. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- [Solid Waste and Recycling]

  A five lesson unit plan by Bernita Robinson. There are activities/lessons focused on litter, paper recycling, solid waste, canned pencils, and plain plane.

- [Throwing It All Away]

  In this lesson plan, grade 6-12 students use a NY Times article as a starting point to "investigate what happens to commonly used items and products once they are thrown away or sent to be recycled, analyzing and understanding the relationship between a product's ingredients and its effects on the environment and on the health of the living things on Earth."

- [To Recycle or Not To Recycle]

  In this webquest, elementary students conduct research on the pros and cons of a mandatory recycling program and present their views to other members of a committee.

- [United States Environmental Protection Agency]

  This comprehensive site from the U.S. Environmental Protection Agency has resources targeted for both students and teachers.

  - [The] Consumer's Handbook for Reducing Solid Waste Practical steps that families can take to reduce the amount and toxicity of garbage.
  - HAZ-ED: Classroom Activities for Understanding Hazardous Waste Teacher resources include downloadable PDF files that offer warm up exercises, activities, fact flashes, and a glossary.
  - Recycle City Students learn about the three R's by touring various sections of

"Recycle City" and seeing how the various organizations and citizens reduce, reuse, and recyle. There's also a "Dumptown game" where students can play the role of a city manager who has been hired to start programs that encourage Dumptown's citizens and businesses to recycle and reduce waste all the while remaining within a budget of course. An Activities section contains suggestions for using the site within the classroom.

- Wastes: Kids Page Online activities for students.
- Waste No Words A crossword puzzle activity.

Water Recycling

Learn how waste water in North Carolina is purified by recycling it a natural way.

Top of Page

Note: The sites listed above will serve as a source of content in Recycling. For other resources in Social Studies - Environment(e.g., curricular content in Biomes, Endangered Species, or Hazardous Waste Disposal), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

Latest News

Powell Cancels Greece Visit Amid Protests (AP)

AP - Secretary of State Colin Powell on Saturday canceled a weekend visit to attend the closing ceremony of the Olympics, just hours after demonstrators marched through central Athens.

Tainted Flu Vaccine May Cause Delay (AP)

AP - U.S. health officials said they do not expect a flu shot shortage after a leading flu vaccine maker warned that it would hold up millions of doses because several batches were contaminated.

Target Shooting Sparked Nevada Wildfire (AP)

AP - Fire officials may impose restrictions on target shooters in this gun-friendly state for the first time after a man with a rifle admitted he started a wildfire that destroyed six houses south of Reno.

Prisoners Take Boy Scout Oath Behind Bars (AP)

AP - Robert Jackson stood with the two dozen other members of Boy Scout Troop 825, raised his right hand in the traditional Boy Scout sign, and took the oath to do his best for God and country.

August Snow Closes Colo. Mountain Roads (AP)

AP - August snows closed two scenic mountain roads and dusted the high peaks with powder, but the early storm doesnt necessarily signal that Colorado is in for a drought-busting winter.

Judge to Rule on Salvadoran Bishop Murder (AP)

AP - In an unusual application of federal law, a judge will rule early next month whether a retired Salvadoran air force captain living in California conspired to kill El Salvadors archbishop 24 years ago.

Environment News

KRL disputes KSPCB claim, insists it is eco-friendly
NewIndPress Aug 28 2004 5:51AM GMT

Bush administration reverses its global warming position
Taipei Times Online Aug 28 2004 5:49AM GMT

Circadian Clock Genes Linked to Mating in Flies
Los Angeles Times Aug 28 2004 7:14AM GMT

Doctors Grow Jaw Bone With Stem Cells
Health Talk Aug 28 2004 6:14AM GMT

Gene may cause inherited Parkinsons
Big News Network Aug 28 2004 5:54AM GMT

Chip-scale atomic clock
PhysOrg.com Aug 28 2004 8:20AM GMT

High up on Temburong Rainforest
Borneo Bulletin Aug 28 2004 8:49AM GMT

Now on Earthtimes you can view the latest environmental and US news plus read or write reviews, shop and search for discount offers. Earthtimes tries to bring the best sites available on the net onto your PC, you are able to read site reviews and new to Earthtimes, cast your vote and rate it or write your own opinions on why you like the site, or what impressed you about it and of course vice versa. To know more check out our WEB PICKS.

Search > [ ] Submit

Publish your thoughts online | Participate in discussions | Make new friends

Recent Articles Posted by users

How Natural Light Affects Home Decor

One of your best friends in design (or worst enemies!) is the natural light that filters through your home's windows.

Google IPO and its effect on the Venture Capital Industry

"Will the Google IPO have any impact on the Venture Capital market?"

"The Two Sides of Medicine"

Throughout time there have always been two opposing points of view as to how to maintain good health, or how to regain it after having lost it. This conflict has continued since ancient times ... and no doubt will continue well into the future.

A Martian Anthropologist Takes A Look At Our Food

We go to the store and turn on the television to be confronted by the most amazing shades of neon, and a circus of novelty products all of which are sold in the food section of every local grocery store. But we have to ask ourselves a very basic question: are these products even food at all?

Working Full Time through Pregnancy

It's not easy working a full time job throughout your pregnancy. You may be at work out of choice, or out of necessity, but either way you need to take some extra precautions in taking care of yourself during the coming months.

Toxic Mystery To Those Who Don't Want To Know!

New research has shown that dozens of toxic industrial chemicals are accumulating in our bodies, and they say theres nothing we can do about it.

New Mom...New Baby...New Debt?

Ah, there is nothing like being an expectant mom. Along with your expanding waistline comes the ever growing list of products for you and your new bundle of joy.

THE FACTS OF LIFE - WHAT EVERY WOMAN SHOULD KNOW ABOUT MONEY (WHETHER MARRIED OR SINGLE)

How to make the most of your money... "Money can't buy you happiness. But it helps you to be miserable in comfort."

"What Did You Have For Breakfast?"

Why is eating a good breakfast so important? Let's find out. What did you have for breakfast? Nothing? Sweet roll and juice, donuts and coffee. Or bacon, eggs, toast with jam, juice, milk.

School Lunches the Frugal Way!

It seems that school starts earlier every year. So it's time to start thinking about what to put in those school lunches every morning.

Recent Actions
General Conformity Regulations
Actions sorted by CAA Title
News and Bulletins
General Documents
Clean Air Updates

Health and Environmental Effects of Ground-Level Ozone

United States Environmental Protection Agency
Office of Air & Radiation
Office of Air Quality Planning & Standards

FACT SHEET

July 17, 1997

HEALTH AND ENVIRONMENTAL EFFECTS OF GROUND-LEVEL OZONE

Why are We Concerned about Ground-Level Ozone?

- Ozone is the prime ingredient of smog in our cities and other areas of the country. Though it occurs naturally in the stratosphere to provide a protective layer high above the earth, at ground-level it is the prime ingredient of smog.
- When inhaled, even at very low levels, ozone can:
  - cause acute respiratory problems;
  - aggravate asthma;
  - cause significant temporary decreases in lung capacity of 15 to over 20 percent in some healthy adults;
  - cause inflammation of lung tissue;
  - lead to hospital admissions and emergency room visits [10 to 20 percent of all summertime respiratory-related hospital visits in the northeastern U.S. are associated with ozone pollution]; and
  - impair the body's immune system defenses, making people more

susceptible to respiratory illnesses, including bronchitis and pneumonia.

Who is Most at Risk from Exposure to Ground-Level Ozone?

- Children are most at risk from exposure to ozone:
  - The average adult breathes 13,000 liters of air per day. Children breathe even more air per pound of body weight than adults.
  - Because children's respiratory systems are still developing, they are more susceptible than adults to environmental threats.
  - Ground-level ozone is a summertime problem. Children are outside playing and exercising during the summer months at summer camps, playgrounds, neighborhood parks and in backyards.
- Asthmatics and Asthmatic Children:
  - Asthma is a growing threat to children and adults. Children make up 25 percent of the population and comprise 40 percent of the asthma cases.
  - Fourteen Americans die every day from asthma, a rate three times greater than just 20 years ago. African-Americans die at a rate six times that of Caucasians.
  - For asthmatics having an attack, the pathways of the lungs become so narrow that breathing becomes akin to sucking a thick milk shake through a straw.
  - Ozone can aggravate asthma, causing more asthma attacks, increased use of medication, more medical treatment and more visits to hospital emergency clinics.
- Healthy Adults:
  - Even moderately exercising healthy adults can experience 15 to over 20 percent reductions in lung function from exposure to low levels of ozone over several hours.
  - Damage to lung tissue may be caused by repeated exposures to ozone -- something like repeated sunburns of the lungs -- and this could result in a reduced quality of life as people age. Results of animal studies indicate that repeated exposure to high levels of ozone for several months or more can produce permanent structural damage in the lungs.
  - Among those most at risk to ozone are people who are outdoors and moderately exercising during the summer months. This includes construction workers and other outdoor workers.

How does Ground-Level Ozone Harm the Environment?

- Ground-level ozone interferes with the ability of plants to produce and store food, so that growth, reproduction and overall plant health are compromised.
- By weakening sensitive vegetation, ozone makes plants more susceptible to disease, pests, and environmental stresses.
- Ground-level ozone has been shown to reduce agricultural yields for many economically important crops (e.g., soybeans, kidney beans, wheat, cotton).

- The effects of ground-level ozone on long-lived species such as trees are believed to add up over many years so that whole forests or ecosystems can be affected. For example, ozone can adversely impact ecological functions such as water movement, mineral nutrient cycling, and habitats for various animal and plant species.
- Ground-level ozone can kill or damage leaves so that they fall off the plants too soon or become spotted or brown. These effects can significantly decrease the natural beauty of an area, such as in national parks and recreation areas.
- One of the key components of ozone, nitrogen oxides, contributes to fish kills and algae blooms in sensitive waterways, such as the Chesapeake Bay.

What Improvement Would Result from EPA's New Standards?

EPA's new ozone standards will provide increased protection beyond that provided by the previous standard from the following effects:

- Reduced risk of significant decreases (15% to over 20%) in children's lung functions (such as difficulty in breathing or shortness of breath), approximately 1 million fewer incidences each year, which can limit a healthy child's activities or result in increased medication use, or medical treatment, for children with asthma
- Reduced risk of moderate to severe respiratory symptoms in children, hundreds of thousands of fewer incidences each year of symptoms such as aggravated coughing and difficult or painful breathing
- Reduced risk of hospital admissions and emergency room visits for respiratory causes, thousands fewer admissions and visits for individuals with asthma
- Reduced risks of more frequent childhood illnesses and more subtle effects such as repeated inflammation of the lung, impairment of the lung's natural defense mechanisms, increased susceptibility to respiratory infection, and irreversible changes in lung structure. Such risks can lead to chronic respiratory illnesses such as emphysema and chronic bronchitis later in life and/or premature aging of the lungs
- Reduce the yield loss of major agricultural crops, such as soybeans and wheat, and commercial forests by almost $500,000,000.

Background: What is Ground-level Ozone?

- Ozone is not emitted directly into the air, but is formed by gases called nitrogen oxides (NOx) and volatile organic compounds (VOCs) that in the presence of heat and sunlight react to form ozone. Ground-level ozone forms readily in the atmosphere, usually during hot weather.
- NOx is emitted from motor vehicles, power plants and other sources of combustion. VOCs are emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial sources.
- Changing weather patterns contribute to yearly differences in ozone concentrations from city to city. Also, ozone and the pollutants that cause ozone can be carried to an area from pollution sources located hundreds of miles upwind.

United States Environmental Protection Agency

GLOBAL WARMING Kids Site

Links! Games!

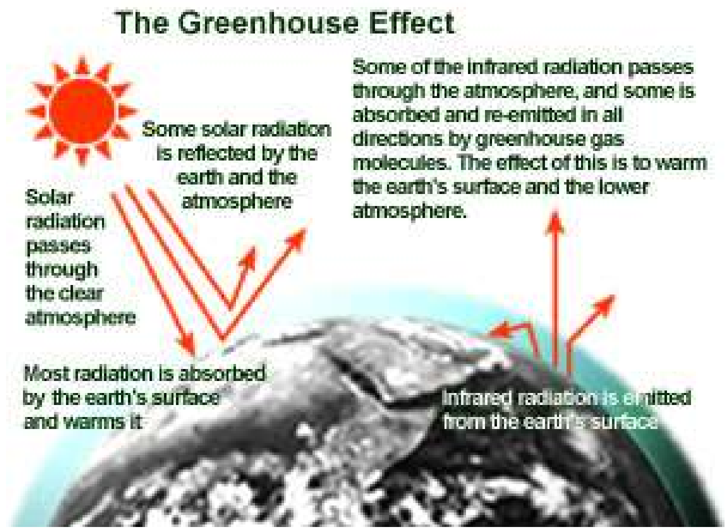
- Global Warming (What it is)
- Climate & Weather
- Greenhouse Effect
- What is the Climate System?
- Climate's Come a Long Way!
- The Climate Detectives...
- Can We Change the Climate?
- So What's the BIG DEAL?
- We CAN Make a Difference!

Greenhouse Effect...

The greenhouse effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere (water vapor, carbon dioxide, nitrous oxide, and methane, for example) trap energy from the sun. Without these gases, heat would escape back into space and Earth's average temperature would be about 60ºF colder. Because of how they warm our world, these gases are referred to as greenhouse gases.

Have you ever seen a greenhouse? Most greenhouses look like a small glass house. Greenhouses are used to grow plants, especially in the winter. Greenhouses work by trapping heat from the sun. The glass panels of the greenhouse let in light but keep heat from escaping. This causes the greenhouse to heat up, much like the inside of a car parked in sunlight, and keeps the plants warm enough to live in the winter.

The Earth's atmosphere is all around us. It is the air that we breathe. Greenhouse gases in the atmosphere behave much like the glass panes in a greenhouse. Sunlight enters the Earth's atmosphere, passing through the blanket of greenhouse gases. As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy. Once absorbed, this energy is sent back into the atmosphere. Some of the energy passes back into space, but much of it remains trapped in the atmosphere by the greenhouse gases, causing our world to heat up.



(D)

The greenhouse effect is important. Without the greenhouse effect, the Earth would not be warm enough for humans to live. But if the greenhouse effect becomes stronger, it could make the Earth warmer than usual. Even a little extra warming may cause problems for humans, plants, and animals.

See an animation of how enhancing the greenhouse effect likely contributes to global warming. *(Macromedia Flash* EXIT disclaimer *Version 5 or higher plug-in required)*

next . . .

Global Warming Home || Privacy and Security Notice || Glossary || Comments
Global Warming Search || EPA Home

See Also:

Ozone Publications

Ozone

What is Ozone?

Ozone is a form of oxygen with three atoms, instead of the usual two atoms. It is a photochemical oxidant and, at ground level, is the main component of smog. Ozone is not emitted directly into the air but is formed through chemical reactions between natural and man-made emissions of volatile organic compounds (VOCs) and nitrogen oxides in the presence of sunlight. These gaseous compounds mix like a thin soup in the ambient, or outdoor, air, and when they interact with sunlight, ozone is formed. Sources of these pollutants include automobiles, gas-powered motors, refineries, chemical manufacturing plants, solvents used in dry cleaners and paint shops, and wherever natural gas, gasoline, diesel fuel, kerosene, and oil are combusted.

Ozone pollution is the periodic increase in the concentration of ozone in the ambient air, the natural air that surrounds us. It is mainly a daytime problem during summer months because warm temperatures play a role in its formation. When temperatures are high, sunshine is strong, and winds are weak, ozone can accumulate to unhealthful levels.

Ground-level ozone is the most prevalent air pollutant in Texas and the nation. Ozone is often one of several pollutants that make up "smog," which you may recognize as the reddish-brown haze that forms when air quality is particularly poor. But because ozone itself is colorless, the air can look clear even when high ozone concentrations are present.

Ozone Is a Health Hazard

The biggest concern with high ozone concentration is the damage it causes to human health, vegetation, and to many common materials we use.

High concentrations of ozone can cause shortness of breath, coughing, wheezing, headaches, nausea, eye and throat irritation, and lung damage. People who suffer from lung diseases like bronchitis, pneumonia, emphysema, asthma, and colds have even more trouble breathing when the air is polluted. These effects can be worse in anyone who spends significant periods of time exercising or working outdoors.

Children often play outside for long periods during the summer. Their lungs are still developing, and they breathe more rapidly and inhale more air pollution per pound of body weight than adults. On days when ozone levels are high, these factors put children at increased risk for respiratory problems.

Adults breathe more than 10,000 times each day. During exercise or strenuous work, we breathe more often and draw air more deeply into the lungs. When we exercise heavily, we may increase our intake of air by as much as 10 times our level at rest. The interaction between air pollution and exercise is so strong that health scientists typically use exercising volunteers in their research.

Materials damaged by ozone include rubber, nylon, plastics, dyes, and paints. Also, many food crops are damaged by ground-level ozone each year.

Ozone levels are considered by the U.S. Environmental Protection Agency (EPA) to be "unhealthful" and exceed the National Ambient Air Quality Standard when they are measured at 125 parts per billion (ppb) or higher under the one-hour standard or at 85 ppb or higher under the eight-hour standard. When a single monitoring site has exceeded the one-hour standard on more than three days in three years, the EPA classifies the surrounding county or metropolitan area as not attaining the ozone standard, or "nonattainment" for ozone. Those areas in "attainment" of the one-hour standard are required to meet the eight-hour standard of a three-year average of the fourth-highest daily maximum eight-hour concentration measured at each site not to be at or exceed 85 ppb.

Status of Texas Metropolitan Areas (One-Hour Standard)

- Houston/Galveston/Brazoria - Nonattainment
- Dallas/Ft. Worth - Nonattainment (Collin, Dallas, Denton, and Tarrant counties)
- El Paso - Nonattainment
- Beaumont/Port Arthur - Nonattainment
- Austin - Attainment
- San Antonio - Attainment
- Corpus Christi - Flexible Attainment
- Tyler/Longview/Marshall - Flexible Attainment

The EPA will announce the attainment/nonattainment status of Texas' metropolitan areas under the eight-hour standard in 2000.

What Can We Do About It?

The TNRCC has developed the Ozone Action Days Program to help the citizens of Texas understand the ozone problem and do their part in preventing ozone formation. The agency forecasts days when conditions are likely to be favorable for ozone formation. The program asks people to take voluntary action on those days to prevent exceedances of the National Ambient Air Quality Standards for ozone.

Since automobiles are the main culprit in ozone formation in Texas, we should try to limit our driving on Ozone Action Days. Actions like car pooling, riding the bus, riding a bicycle, consolidating errands, and avoiding rush hour add up to less pollution.

There are a number of voluntary steps that individuals, businesses, and industry can take to limit their pollutant emissions on Ozone Action Days.

Ozone Readings in Texas

The TNRCC collects daily ozone measurements at several monitors across the state. Peak ozone concentrations found yesterday in the state's major metropolitan areas are available as well as daily peaks since January 1, 1998. Today's peak ozone concentrations are also available. These concentrations are used in determining if the National Ambient Air Quality Standard has been exceeded.

The Air Quality Index (AQI), formerly known as the Pollution Standard Index (PSI), is derived from air pollutant measurements and is used to determine an AQI rating of "Good," "Moderate," or "Unhealthful." Because ozone measurements are usually higher in Texas than those of other air pollutants, the AQI is normally based on ozone levels.

Historical Trend

Major metropolitan areas of Texas have experienced a steady decline in ozone levels over the past 20 years due to factors such as the production of reformulated gasoline and better automobile emission controls. Levels in 1987 contradicted the overall downward trend as a result of a heat wave present during that season. A similar heat wave in 1995 caused ozone levels to be higher than the trend would suggest.

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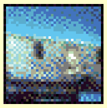
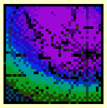
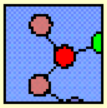


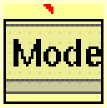
I: The Discovery of the Ozone Hole



II: Recent Ozone Loss over Antarctica



III: The Science of the Ozone Hole



IV: Latest Ozone Hole Research at Cambridge

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 This version designed and maintained by Dr. Glenn Carver. Original concept and design Owen Garrett. French translation by Dr. Hubert Teyssèdre, German translation by Dr. Olaf Morgenstern.

We have reorganized our information.

Please refer to our new site:

" Stratospheric Ozone " (www.ec.gc.ca/ozone)

and update your bookmarks.

NOAA Technical Memorandum NWS SR-145

A COMPREHENSIVE GLOSSARY OF WEATHER TERMS FOR STORM SPOTTERS

Michael Branick
NOAA/WFO Norman

Contents

Introduction to the First Edition

This glossary contains weather-related terms that may be either heard or used by severe local storm spotters or spotter groups. Its purposes are 1) to achieve some level of standardization in the definitions of the terms that are used, and 2) provide a reference from which the meanings of any terms, especially the lesser-used ones, can be found. The idea is to allow smooth and effective communication between storm spotters and forecasters, and vice versa. This is an important necessity within the severe weather warning program. Despite advances in warning and forecasting techniques (e.g., Doppler radar), the human eye will always be a vital part of any effective warning system. *Storm spotters are, and always will be, an indispensable part of the severe local storm warning program.*

A complete list of terms probably is impossible to arrive at, but this list is as comprehensive as possible. Certainly it is not necessary for every spotter to know the meaning of *every* term contained herein. In this sense, the glossary serves as a reference. In fact, many of the terms may never be heard at all; they are included here just in case, someday, they are. (By the way, inclusion of a term in this glossary does *not* give license to use it freely in radio or phone communication. Use of technical terms should be kept to a minimum.) But there are some terms for which the meanings are both important and specific. The important ones are preceded by asterisks; all spotters should be familiar with the definitions of these terms before taking an active role in any spotter group.

I have written the definitions in what hopefully passes as "layman's terms." They are written to be easily understood by the storm spotter, regardless of his or her meteorological background. At times I have sacrificed technical purity for simplicity, and the result may prompt a few moans from the technical purists. So be it; this glossary wasn't written for them. Many of the terms are so closely interrelated, though, that it becomes necessary to "cross-reference;" that is, to use one or more terms in the definition of another. In this glossary, all terms that are hyperlinked within a definition are terms that are defined themselves elsewhere.

The glossary is a culmination of an effort which began in the spring of 1991. Many individuals with considerable experience in severe storm research and storm spotting (or chasing) contributed to the glossary. Because of the many comments offered by these individuals, there was disagreement on the descriptions of some terms. Those terms that were identified as such as being somewhat more controversial are handled in the text by inclusion of a second paragraph in the description, which discusses any cautions or controversy regarding the use of the term.

One last word: Storm spotting is vital, but also can be very dangerous. *No one should attempt storm spotting without first obtaining the proper training!* This glossary in itself is not to be considered sufficient training material to qualify oneself as a spotter. Further training, usually provided by the National Weather Service, must be obtained through local agencies (usually Emergency Management) before one can be certified as a storm spotter. There is also something to be said for the so-called storm chasers, who chase storms mainly for the thrill of it (and as such are *not* spotters). Chasers of all levels of background and experience will no doubt find this glossary useful or at least interesting. But while I commend their enthusiasm, I must emphasize that the glossary does *not* condone storm chasing as a leisure activity - especially for the unprepared. Proper training and foreknowledge of the dangers are required of everyone who meets face to face with severe thunderstorms - regardless of the reason for the encounter.

Michael L. Branick
National Weather Service, Experimental Forecast Facility
Norman, Oklahoma
June 1992

Introduction to the Second Edition

Based on feedback since its introduction, the "Spotter Glossary" (as this glossary has come to be known) has achieved considerable popularity among spotters - at least in the southern Plains region of "Tornado Alley." In this region, spotters actively seek as much information as possible when assessing severe weather potential on a given day. The information available often includes products which contain technical terms which are more esoteric to operational meteorology, and less familiar to those who do not pursue meteorology as a living. Examples include forecast discussions issued by local National Weather Service offices, and convective outlooks and discussions issued by the Storm Prediction Center (SPC, formerly known as SELS/NSSFC).

The question arises as to just how far one should go into the technical realm of operational meteorology when compiling a glossary like this for storm spotters. The dilemma is thus: The spotters' thirst for knowledge is admirable, but how much of the technical jargon *really* needs to be understood by spotters in the field?

I certainly do not want to turn the glossary into a meteorological textbook for spotters (or anyone else). That is not its purpose. Spotters have a vital role in the warning program, as do forecasters. And while interaction between them is an absolute necessity, one must be careful not to allow the two functions to overlap so much that we end up with spotters routinely generating their own forecasts and disregarding those made by the forecasters. That is not the spotter's function; spotting is.

On the other hand, I applaud the spotters who demonstrate a genuine interest in understanding the atmosphere that they are trained to observe. If they are interested in understanding what the forecaster is talking about when he/she refers to, say, "isentropic lift" or a "right-rear quad of an upper jet max", then they should have a place to find at least a general description of the unfamiliar terms. This is preferable to saying, "you don't need to know that." And those who are "turned off" by the technical jargon need not look into it further.

I have attempted to "strike a happy medium" by adding a number of meteorological terms and phrases to this edition, accompanied by general definitions. New terms to this addition, many of which were added at the suggestion of spotters, are listed below. They at least should help the spotter to understand a little more about why a particular feature is important to severe weather forecasting. Those who wish to pursue a particular issue beyond what is covered in this glossary are directed to the local library or the nearest university meteorology department.

Note that a similar dilemma arose in the first edition, regarding the inclusion of "slang" terms that are used most often by storm chasers. Again I distinguish between chasers and spotters - the former tending to observe storms for their own gratification, the latter tending to do so more for the needs of the community. The "slang" dilemma continues, but as with the first edition I have gone ahead and included many slang terms that I consider appropriate for spotter use. That means that terms like "Caprock delight" (which may be anything *but* a delight to residents in the path of one) will not be found herein, but that slang terms that are more-or-less universally accepted, such as "bear's cage" or "anvil crawlers," probably will appear.

Finally, modernization of the National Weather Service requires a few updates. NMC now is NCEP; SELS now is SPC. The Eta and RUC models are now here. And NEXRAD is no longer the NEXt-generation weather RADar, but is here now. The latest changes have been incorporated accordingly into the glossary.

Mike Branick
September 1996

List of words added in the second edition

Glossary

Quick Alpha Access:
A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

-A-

AC - Convective outlook issued by the SPC. Abbreviation for **A**nticipated **C**onvection; the term originates from the header coding [ACUS1] of the transmitted product. See SWODY1, SWODY2.

ACCAS (usually pronounced ACK-kis) - **A**lto**C**umulus **CAS**tellanus; mid-level clouds (bases generally 8 to 15 thousand feet), of which at least a fraction of their upper parts show cumulus-type development. These clouds often are taller than they are wide, giving them a turret-shaped appearance. ACCAS clouds are a sign of instability aloft, and may precede the rapid development of thunderstorms.

Accessory Cloud - A cloud which is dependent on a larger cloud system for development and continuance. Roll clouds, shelf clouds, and wall clouds are examples of accessory clouds.

Advection - Transport of an atmospheric property by the wind. See cold advection, moisture advection, warm advection.

Air-mass Thunderstorm - Generally, a thunderstorm not associated with a front or other type of synoptic-scale forcing mechanism. Air mass thunderstorms typically are associated with warm, humid air in the summer months; they develop during the afternoon in response to insolation, and dissipate rather quickly after sunset. They generally are less likely to be severe than other types of thunderstorms, but they still are capable of producing downbursts, brief heavy rain, and (in extreme cases) hail over 3/4 inch in diameter. See popcorn convection.

Since all thunderstorms are associated with some type of forcing mechanism, synoptic-scale or otherwise, the existence of true air-mass thunderstorms is debatable. Therefore the term is somewhat controversial and should be used with discretion.

Algorithm - A computer program (or set of programs) which is designed to systematically solve a certain kind of problem. WSR-88D radars (NEXRAD) employ algorithms to analyze radar data and automatically determine storm motion, probability of hail, VIL, accumulated rainfall, and several other parameters.

Anticyclonic Rotation - Rotation in the opposite sense as the Earth's rotation, i.e., clockwise in the Northern Hemisphere as would be seen from above. The opposite of cyclonic rotation.

Anvil - The flat, spreading top of a Cb (cumulonimbus), often shaped like an anvil. Thunderstorm anvils may spread hundreds of miles downwind from the thunderstorm itself, and sometimes may spread upwind (see back-sheared anvil).

Anvil Crawler - [Slang], a lightning discharge occurring within the anvil of a thunderstorm, characterized by one or more channels that appear to crawl along the underside of the anvil. They typically appear during the weakening or dissipating stage of the parent thunderstorm, or during an active MCS.

Anvil Dome - A large overshooting top or penetrating top.

Anvil Rollover - [Slang], a circular or semicircular lip of clouds along the underside of the upwind part of a back-sheared anvil, indicating rapid expansion of the anvil. See cumuliform anvil, knuckles, mushroom.

Anvil Zits - [Slang], frequent (often continuous or nearly continuous), localized lightning discharges occurring from within a thunderstorm anvil.

AP - Anomalous Propagation. Radar term for false (non-precipitation) echoes resulting from nonstandard propagation of the radar beam under certain atmospheric conditions.

Approaching (severe levels) - A thunderstorm which contains winds of 35 to 49 knots (40 to 57 mph), or hail 1/2 inch or larger but less than 3/4 inch in diameter. See severe thunderstorm.

Arcus - A low, horizontal cloud formation associated with the leading edge of thunderstorm outflow (i.e., the gust front). Roll clouds and shelf clouds both are types of arcus clouds.

AVN - AViatioN model; one of the operational forecast models run at NCEP. The AVN is run four times daily, at 0000, 0600, 1200, and 1800 GMT. As of fall 1996, forecast output was available operationally out to 120 hours only from the 0000 and 1200 runs. At 0600 and 1800, the model is run only out to 72 hours.

-B-

Back-building Thunderstorm - A thunderstorm in which new development takes place on the upwind side (usually the west or southwest side), such that the storm seems to remain stationary or propagate in a backward direction.

Backing Winds - Winds which shift in a counterclockwise direction with time at a given location (e.g. from southerly to southeasterly), or change direction in a counterclockwise sense with height (e.g. westerly at the surface but becoming more southerly aloft). The opposite of veering winds.

In storm spotting, a backing wind usually refers to the turning of a south or southwest surface wind with time to a more east or southeasterly direction. Backing of the surface wind can increase the potential for tornado development by increasing the directional shear at low levels.

Back-sheared Anvil - [Slang], a thunderstorm anvil which spreads upwind, against the flow aloft. A back-sheared anvil often implies a very strong updraft and a high severe weather potential. (See Fig. 7, supercell.)

Barber Pole - [Slang], a thunderstorm updraft with a visual appearance including cloud striations that are curved in a manner similar to the stripes of a barber pole. The structure typically is most pronounced on the leading edge of the updraft, while drier air from the rear flank downdraft often erodes the clouds on the trailing side of the updraft.

Baroclinic Zone - A region in which a temperature gradient exists on a constant pressure surface. Baroclinic zones are favored areas for strengthening and weakening systems; barotropic systems, on the other hand, do not exhibit significant changes in intensity. Also, wind shear is characteristic of a baroclinic zone.

Barotropic System - A weather system in which temperature and pressure surfaces are coincident, i.e., temperature is uniform (no temperature gradient) on a constant pressure surface. Barotropic systems are characterized by a lack of wind shear, and thus are generally unfavorable areas for severe thunderstorm development. See baroclinic zone.

Usually, in operational meteorology, references to barotropic systems refer to *equivalent* barotropic systems - systems in which temperature gradients exist, but are parallel to height gradients on a constant pressure surface. In such systems, height contours and isotherms are parallel everywhere, and winds do not change direction with height.

As a rule, a true equivalent barotropic system can never be achieved in the real atmosphere. While some systems (such as closed lows or cutoff lows) may reach a state that is close to equivalent barotropic, the term barotropic system usually is used in a relative sense to describe systems that are really only close to being equivalent barotropic, i.e., isotherms and height contours are nearly parallel everywhere and directional wind shear is weak.

Bear's Cage - [Slang], a region of storm-scale rotation, in a thunderstorm, which is wrapped in heavy precipitation. This area often coincides with a radar hook echo and/or mesocyclone, especially one associated with an HP storm.

The term reflects the danger involved in observing such an area visually, which must be done at close range in low visibility.

Beaver('s) Tail - [Slang], a particular type of inflow band with a relatively broad, flat appearance suggestive of a beaver's tail. It is attached to a supercell's general updraft and is oriented roughly parallel to the pseudo-warm front, i.e., usually east to west or southeast to northwest. As with any inflow band, cloud elements move toward the updraft, i.e., toward the west or northwest. Its size and shape change as the strength of the inflow changes. See also inflow stinger.

Spotters should note the distinction between a beaver tail and a tail cloud. A "true" tail cloud typically is attached to the wall cloud and has a cloud base at about the same level as the wall cloud itself. A beaver tail, on the other hand, is not attached to the wall cloud and has a cloud base at about the same height as the updraft base (which by definition is higher than the wall cloud). Unlike the beaver tail, the tail cloud forms from air that is flowing from the storm's main precipitation cascade region (or outflow region). Thus, it can be oriented at a large angle to the pseudo-warm front.

Blue Watch (or Blue Box) - [Slang], a severe thunderstorm watch.

Boundary Layer - In general, a layer of air adjacent to a bounding surface. Specifically, the term most often refers to the *planetary boundary layer*, which is the layer within which the effects of friction are significant. For the earth, this layer is considered to be roughly the lowest one or two kilometers of the atmosphere. It is within this layer that temperatures are most strongly affected by daytime insolation and nighttime radiational cooling, and winds are affected by friction with the earth's surface. The effects of friction die out gradually with height, so the "top" of this layer cannot be defined exactly.

There is a thin layer immediately above the earth's surface known as the *surface boundary layer* (or simply the surface layer). This layer is only a part of the planetary boundary layer, and represents the layer within which friction effects are more or less constant throughout (as opposed to decreasing with height, as they do above it). The surface boundary layer is roughly 10 meters thick, but again the exact depth is indeterminate. Like friction, the effects of insolation and radiational cooling are strongest within this layer.

Bow Echo - A radar echo which is linear but bent outward in a bow shape (Fig. 1). Damaging straight-line winds often occur near the "crest" or center of a bow echo. Areas of circulation also can develop at either end of a bow echo, which sometimes can lead to tornado formation - especially in the left (usually northern) end, where the circulation exhibits cyclonic rotation.

Box (or Watch Box) - [Slang], a severe thunderstorm or tornado watch. See blue box, red box.

BRN - See Bulk Richardson Number.

Bubble High - A mesoscale area of high pressure, typically associated with cooler air from the rainy downdraft area of a thunderstorm or a complex of thunderstorms. A gust front or outflow boundary separates a bubble high from the surrounding air.

Bulk Richardson Number (or BRN) - A non-dimensional number relating vertical stability and vertical shear (generally, stability divided by shear). High values indicate unstable and/or weakly-sheared environments; low values indicate weak instability and/or strong vertical shear. Generally, values in the range of around 50 to 100 suggest environmental conditions favorable for supercell development.

Bust - [Slang], an inaccurate forecast or an unsuccessful storm chase; usually a situation in which thunderstorms or severe weather are expected, but do not occur.

BWER - **B**ounded **W**eak **E**cho **R**egion. (Also known as a vault.) Radar signature within a thunderstorm characterized by a local minimum in radar reflectivity at low levels which extends upward into, and is surrounded by, higher reflectivities aloft (Fig. 2). This feature is associated with a strong updraft and is almost always found in the inflow region of a thunderstorm. It cannot be seen visually. See WER.

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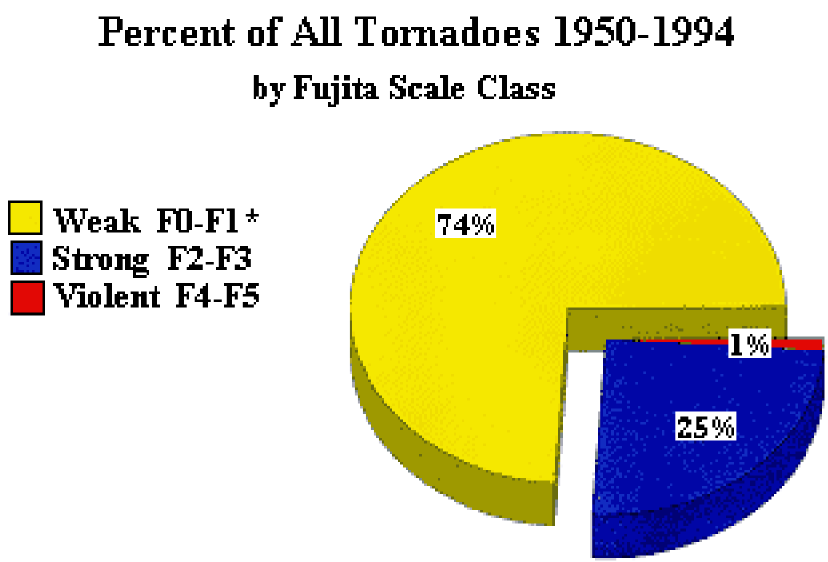
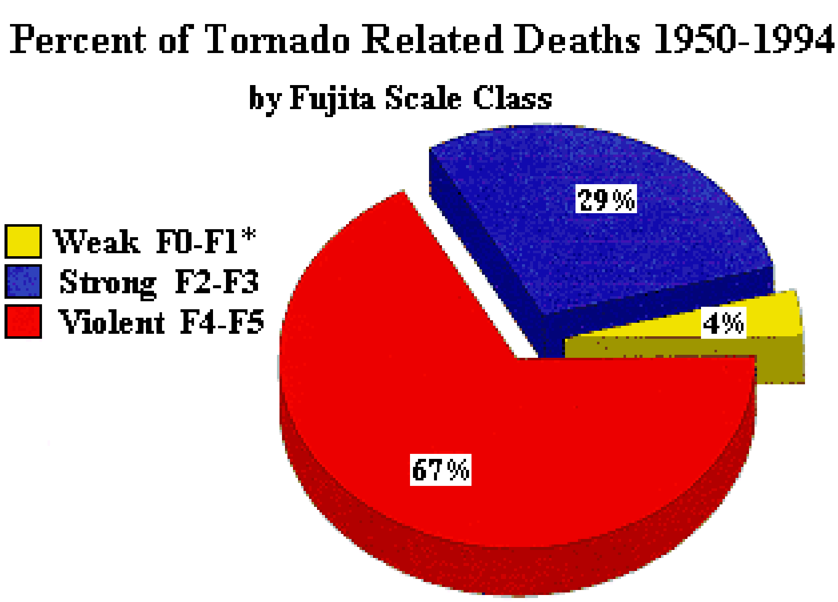
The Fujita Scale

The Fujita Scale is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure.



The **"Percentage of All Tornadoes 1950-1994" pie chart** reveals that the vast majority of tornadoes are either weak or do damage that can only be attributed to a weak tornado. Only a small percentage of tornadoes can be correctly classed as violent. Such a chart became possible only after the acceptance of the Fujita Scale as the official classification system for tornado damage. It is quite possible that an even higher percentage of all tornadoes are weak. Each year the National Weather Service documents about 1000 tornado touchdowns in the United States. There is evidence that 1000 or more additional weak tornadoes may occur each year and go completely undocumented.



The **"Percentage of Tornado-Related Deaths 1950-1994" pie chart** shows that while violent tornadoes are few in number, they cause a very high percentage of tornado-related deaths. The Tornado Project has analyzed data prior to 1950, and found that the percentage of deaths from violent tornadoes was even greater in the past. This is because the death tolls prior to the introduction of the forecasting/awareness programs were enormous: 695

dead(Missouri-Illinois-Indiana, March 18, 1925); 317 dead(Natchez, Mississippi, May 7, 1840);.255 dead(St. Louis, Missouri and East St. Louis, Illinois, May 27, 1896); 216 dead(Tupelo, Mississippi, April 5, 1936); 203 dead(Gainesville, GA, April 6, 1936). In more recent times, no single tornado has killed more than 50 people since 1971.

The Fujita Scale(also known as the Fujita-Pearson Scale) may not be a perfect system for linking damage to wind speed, but it had distinct advantages over what had gone on before its inception. And it was simple enough to use in daily practice without involving much additional expenditure of time or money. From a practical point of view, it is doubtful that any other system would have found its way into widespread accepted use, even to this day. The entire premise of estimating wind speeds from damage to non-engineered structures is very subjective and is difficult to defend from various meteorological perspectives. Nothing less than the combined influence and and prestige of the late Professor Fujita and Allen Pearson, director of NSSFC(National Severe Storm Forecast Center) in 1971 could have brought this much needed system into widespread use. The FPP scale rates the intensity of the tornado, and measured both the path length and the path width. The Fujita part of the scale is as follows:

The Fujita Scale

F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
F0	Gale tornado	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.

F1	**Moderate tornado**	**73-112 mph**	**The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.**
F2	**Significant tornado**	**113-157 mph**	**Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.**
F3	**Severe tornado**	**158-206 mph**	**Roof and some walls torn off well constructed houses; trains overturned; most trees in fores uprooted**
F4	**Devastating tornado**	**207-260 mph**	**Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.**

F5	**Incredible tornado**	**261-318 mph**	**Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-inforced concrete structures badly damaged.**
F6	**Inconceivable tornado**	**319-379 mph**	**These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies**

A key point to remember is this: ***the size of a tornado is not necessarily an indication of its intensity.*** Large tornadoes ***can*** be weak, and small tornadoes ***can*** be violent. A good example of a relatively "small" tornado would be the Pampa, Texas tornado of 1995, which can be seen in Tornado Video Classics III. This tornado is pictured on the right side of the slipcase, shown here.

Notice the debris in the air. Eyewitnesses to this tornado claim to have seen as many as 6 vehicles in the air at the same time when it passed over a parking lot. Another consideration is the stage in the life cycle of the tornado. A "small" tornado may have been larger, and is at the "shrinking" stage of its life cycle, like the Tracy, Minnesota tornado on one of our posters, and also our logo, seen on the navigation bar to the left if you are using our frames. Large tornadoes can also be strong and small tornadoes can be weak. The Fujita Scale is based on ***damage***, not the appearance of the funnel. Storm spotters, storm chasers and other weather observers often try to estimate the intensity of a tornado when they are in the field, basing their judgement on the rotational speed and amount of debris being generated as well as the width. However, the official estimate is made ***after*** the tornado has passed. Personnel from the National Weather Service office that issued the warning survey the site to determine the F-Scale rating. Sometimes they call in experts from out of the area. Aerial surveys are occasionally done after violent tornadoes to determine the exact damage track. Insurance companies may also call in wind engineers to do their own evaluations, but the official rating is set by the NWS. A few of the things they all look for are:

- attachment of the walls and floor to the foundation of the building
- attachment of the roof to the rafters and walls
- whether or not there are steel reinforcing rods in concrete or cinder block walls
- whether there is mortar between the cinder blocks

After the NWS office does the survey, the official rating is recorded, and eventually posted at the SPC site. If it is a killer tornado we also post the rating on our site with the description of the event, and on our "all tornadoes" page. The NWS office may also write up a more extensive report, which may or may not be posted on the web. A good example of such a report would be the one done on the Florida tornadoes of March, 1998.

The Fujita Scale is very subjective, and varies according to how experienced the surveyor is. We have many readers who have tried to do their own "surveys" of tornado damage when storms have occurred in their area. However, the less experienced the surveyor is, the more likely he/she is to be awed by the damage, and the more likely they are to give it a high rating. Brian Smith of the Omaha, Nebraska area NWS office, a former student of Dr. Fujita and an expert frequently brought in to do site surveys, tells of hearing about a tee-shirt with the words "F-3 My Foot" printed on it.

Media hype and inexperience with tornado damage also plays a **big** part in exaggerated F-Scale claims seen on television or in the paper. A reporter may see a collapsed concrete block home and be very impressed, never noticing that there was no mortar between the blocks. They may be aghast to see a park whose trees have been leveled, but not know that the species had very shallow roots, planted in soil that was soft and soggy from torrential rains, and thus easily toppled. They may see a roof that had been blown a quarter of a mile from its house, and not know that the roof was attached to the house with only a few nails, and when lofted into the air, acted as a "sail." They may see a light post that is bent at a 30 degree angle and think that it must have taken a 600 mph wind to do that, not knowing that a van had been blown into the pole, bending it, then been towed off to help clear the streets. For some of the media, the exaggerations make for a better story than the actual facts. Fortunately, they often make up for this by printing helpful stories about aid available and inspirational human interest stories.

As if doing a site survey of a track is not difficult enough, tornadic storms may also be accompanied by complex combinations of strong downbursts and other straight line winds. Separating tornado damage from other wind damage makes for a daunting, difficult task for even the most experienced surveyor.

The Seymour, Texas, tornado of April 10, 1979 is a prime example of a tornado that is destined to be misjudged on the Fujita Scale. This spectacular funnel was probably capable of F4 damage, had it passed through a town. It produced only telephone pole and tree damage, and thus could be rated no higher than F2 damage. The Seymour tornado was in the same family as the devastating Wichita Falls, Texas tornado, which remains as of this writing, the most damaging in US history. Video of this tornado is used in the Fujita Scale segment of Tornado Video Classics II

Professor Fujita continued his work until his death at the age of 78. Mr. Pearson is semi-retired, and is very active on the web.

We recently created four new color posters showing tornadoes of various intensities and identifying their F-Scale ratings. They can be viewed here.

If you want to use frames, you will get more reliable results by using the navigation panel on the left.

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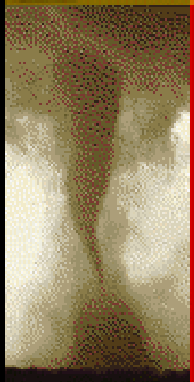

Storm Spotter Glossary Storm Chaser Information

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Twister: The Tornado Story

1. Story map
2. Tornado disaster
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AP Photo/John S. Stewart

Background image: Near Oklahoma City, OK, May 3, 1999.
Photo by Daphne Zaras, courtesy National Severe Storms Laboratory /NOAA

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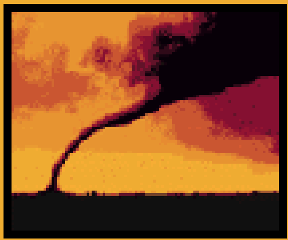

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Is this a record setting year? It could be!

Welcome to the Tornado Project Online! We are a small company that gathers, compiles, and makes tornado information available to weather enthusiasts, the meteorological community and emergency management officials in the form of tornado books, posters, and videos. There are many sites with tornado data, so we are giving the subject a little different twist, with tornado myths, tornado oddities, personal experiences, tornado chasing, tornado safety, and tornadoes in the past as well as more recent tornadoes. We will be adding new pages and have some unique ideas planned during the next few months, so come back often and check us out. You'll be glad you blew in!

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Tornado Field Trip

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Do you recall the tornado in "The Wizard of Oz" that takes Dorothy's house and transplants it to the land of Oz? Well we don't know of any tornadoes that have picked something up and moved it to Oz, but we do know that tornadoes can have unbelievable strength and that trucks and houses *have* been picked up and placed elsewhere. In this field trip students will learn about the conditions that allow tornadoes to form, where these windstorms occur, how they're measured, myths about tornadoes, and how to prepare.

Objectives

- Students will learn about how tornadoes are formed.
- Students will be taken to Web sites where they can research various types of information about tornadoes.

See our Awards

Concepts

1. What conditions allow a tornado to form?
2. Where do most tornadoes occur?
3. What are the typical windspeeds of a tornado?
4. What types of destruction do tornadoes cause?
5. What are some of the strangest occurances tornadoes have caused?
6. How long does a typical tornado last?
7. How far do tornadoes travel during a storm?

Terms To Learn

air pressure
condensation
cumulonimbus cloud
Fujita scale
front
funnel cloud
mesocyclone
Tornado Alley
twister
updraft
wall cloud

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Vortex

Whirling water creates a tornado in a bottle.

Fluids

Water forms a spiraling, funnel-shaped vortex as it drains from a 2-liter soda bottle. A simple connector device allows the water to drain into a second bottle. The whole assembly can then be inverted and the process repeated.

materials

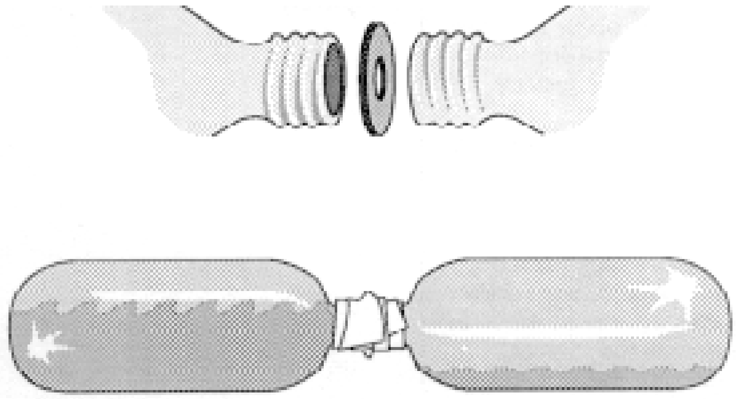
✔ **Two 2-liter soda bottles.**

✔ **A Tornado Tube™** plastic connector (available from science museums, science stores, novelty stores, and some scientific supply companies). Or you can make your own using a washer with a 3/8 inch (9.5 mm) hole and electrical tape.

✔ **Optional:** A small dropper bottle of food coloring and/or bits of paper.

assembly

(5 minutes or less with the Tornado Tube™; 15 minutes or less with the washer and electrical tape)



Fill one of the soda bottles about two-thirds full of water. For effect, you can add a little food coloring or paper bits to the water. Screw the bottles onto both ends of the plastic connector. (CAUTION: Do not screw the connector on too tightly!) Or tape the bottles together with the washer between them.

to do and notice

(15 minutes or more)

Place the two bottles on a table with the filled bottle on top. Watch the water slowly drip down into the lower bottle as air simultaneously bubbles up into the top bottle. The flow of water may come to a complete stop.

With the filled bottle on top, rapidly rotate the bottles in a circle a few times. Place the assembly on a table. Observe the formation of a funnel-shaped *vortex* as the bottle drains.

Notice the shape of the vortex. Also, notice the flow of the water as it empties into the lower bottle.

You can make the vortex with a single bottle by twirling the bottle and holding it over a water basin or the ground to drain, but you lose the water and have to refill the bottle each time you use it.

what's going on?

When the water is not rotating, *surface tension* creates a skinlike layer of water across the small hole in the center of the connector.

If the top bottle is full, the water can push out a bulge in this surface to form a bulbous drop, which then drips into the lower bottle. As water drops into the lower bottle, the pressure in the lower bottle builds until air bubbles are forced into the upper bottle. The pressure that the water exerts on the surface in the connector decreases as the water level in the upper bottle drops. When the water level and pressure drop low enough, the water surface can hold back the water and stop the flow completely.

If you spin the bottles around a few times, the water in the upper bottle starts rotating. As the water drains into the lower bottle, a vortex forms. The water is pulled down and forced toward the drain hole in the center by gravity. If we ignore the small friction forces, the *angular momentum* of the water stays the same as it moves inward. This means that the speed of the water around the center increases as it approaches the center of the bottle. (This is the same reason that the speed of rotating ice skaters increases when they pull in their arms.)

To make water move in a circle, forces called *centripetal forces* must act on the water. These "center pulling" forces are provided by a combination of air pressure, water pressure, and gravity.

You can tell where the centripetal forces are greater by looking at the slope of the water. Where the water is steeper, such as at the bottom of the vortex, the centripetal force on the water is greater. Water moving with higher speeds and in smaller radius curves requires larger forces. The water at the bottom of the vortex is doing just this, and so the wall of the vortex is steepest at the bottom. (Think about race cars: Racetracks have steeper banks on high-speed, sharp corners to hold the cars in their circular paths around the track.)

The hole in the vortex allows air from the lower bottle to flow easily into the upper bottle. This enables the upper bottle to drain smoothly and completely.

etcetera

Vortices occur in nature in many forms: Tornadoes, whirlpools, weather systems, galaxies, etc.

The essence of a vortex is that objects are drawn together toward the center, then miss!

Spiral waves form in the water surface of the vortex. These waves appear to move in slow motion as they travel upward through the downward flowing water.

The Exploratorium's Vortex exhibit was created by artist Douglas Hollis. Related Snacks are Momentum Machine and Spinning Blackboard.

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Like this snack? You can order the snackbook "The Spinning Blackboard" online for more force & motion experiments!

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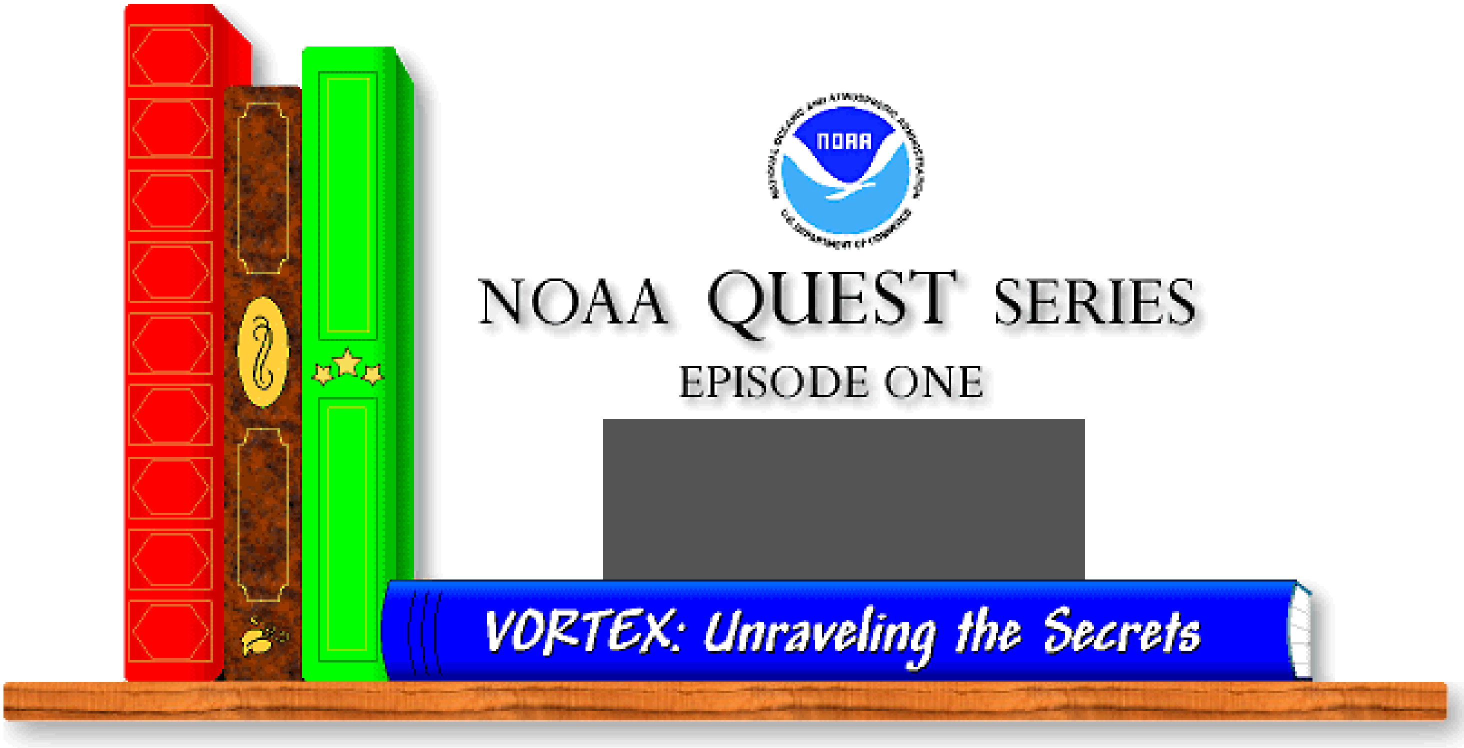

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The new site is at:
http://www.cimms.ou.edu/~doswell/a_tornado/atornado.html

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What is a tornado?

Charles A. Doswell III

Cooperative Institute for Mesoscale Meteorological Studies*

Norman, OK

***Disclaimer:** This essay has not been reviewed by the scientific community and, therefore, can be said to be represent nothing more than a collection of my opinions. It certainly does not have (and I have not sought) the imprimatur of anyone in my official chain of command, and doesn't represent the position of NSSL. My intent in making these opinions available is to discuss some issues and perhaps to stimulate discussion and thought at the same time. Therefore, feedback is welcomed: you can e-mail me at: cdoswell@hoth.gcn.ou.edu.

Last update: **01 October 2001**

What's new: Accounted for the revised Glossary definitions of tornado and waterspout, plus a few minor changes.

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1. Misconceptions

The most widely-accepted definition of a tornado can be found in, among other sources, the *Glossary of Meteorology (Huschke 1959):*

> **Tornado** -- A violently rotating column of air, pendant from a **cumulonimbus** cloud, and nearly always observable as a "funnel cloud" or **tuba**.

Curiously, this definition says nothing about that rotating column being in contact with the surface. Perhaps the next edition of the Glossary will correct this oversight.

Update (01 Oct 2001): In fact, this definition *has* been corrected in the new *Glossary* (Glickman 2000):

> **Tornado** -- 1. A violently rotating column of air, in

> contact with the ground, either pendant from a **cumuliform** cloud or underneath a cumuliform cloud, and often (but not always) visible as a **funnel cloud**.

There is no definition of a tornado that has been extensively peer-reviewed.[4]

A brief digression:

I want to take a moment to gripe about the word **touchdown** in association with tornadoes. I believe that "touchdown" is inappropriate to describe the actual process of tornadic winds commencing at the surface. There is nothing coming down, in the sense that a solid tube would fall out of the sky. What actually goes on when a vortex is present in the atmosphere is that the vortex either (a) is already present at the surface, or (b) wraps around itself, like a smoke ring. If you find this confusing, please see my Vorticity Primer, where this concept is described in some detail. The laws of Fluid dynamics tell us that (a) and (b) are the **only** two options. As noted elswhere [in *formal* form, here], the intense part of the vortex **can** build downward, but this is not the same as a tornado descending. What is actually happening is that the vortex at the surface increases its intensity (and decreasing its scale at the same time) to tornadic proportions, eventually producing winds capable of tornadic damage ... but the vortex itself is almost certainly already in contact with the ground. Strictly speaking, "the vortex" should not be equated to "the tornado," since the vortex can be present but with non-damaging windspeeds. Prior to the commencement of damaging winds at the ground, the surface vortex is weak and spread out ... as it intensifies, the winds increase and the size of the circulation contracts. The vortex also can intensify upward (as we think happens in the tornadoes that are called "landspouts" - see below). Rather than "touchdown" I would prefer to consider the observed process of the commencement of tornadic winds at the surface to be one of "spin-up" ... I hasten to add that "up" in this context does **not** imply ascent, but rather an increase of spin intensity.

Perhaps some of you have seen some video of two funnel clouds that are seen at cloud base ... with time, the vortices curl toward each other and seem to "connect" ... what is happening there is a vortex that wraps around itself, just like a smoke ring. Since air is a fluid, it obeys the laws of fluid dynamics, which include this "law" of vortices (that they either form loops or they end only on a solid surface). NSSL has a photo showing this phenomenon of a vortex ring (see photo #3 in the NSEA Photo Gallery). These have been given the name "bowtie funnels" by some storm chasers.

During our chase in 1989, my partner (Al Moller) and I happened to drive right under a strongly rotating towering cumulus. As it passed overhead, our surface winds changed from southeasterly, to easterly, to northeasterly, to northerly, to northwesterly, to westerly, to southwesterly, all in within a minute or two! At no time were the winds more than 10-15 knots. We experienced a surface vortex of near-tornadic **size** but not of tornadic **intensity**! [an F-(minus)1 tornado?] Later on, this rotating cloud produced a tornado.

The observed "descent" of cloud to form the funnel-shaped cloud of a tornado is also not associated with true descent. As the vortex intensifies, its central pressure falls. When the pressure is reduced to that which permits condensation of water vapor into cloud material, the funnel-shaped cloud appears. It often appears to descend for perhaps two distinct reasons: 1) Near cloud base, the pressure doesn't have to fall as far for the air in the vortex to reach condensation as it does further down, or 2) The circulation intensity is actually increasing downward. We do not know the actual distribution of pressure in tornadoes, of course, and the tornadic pressure field may have many complexities. However, it is unlikely that clouds from above are descending to create the funnel-shaped cloud ... generally, **descent dissipates clouds**. Of course, it could be that descent in the core of a two-celled vortex *might* produce a funnel-shaped cloud simply by pulling down cloud matter in a way that evaporation of the cloud droplets is relatively slow along the axis and relatively faster along the margins, resulting in a tapered funnel. Someday, perhaps we can get some answers ... .

The public at large has many misconceptions about tornadoes, a notable one being that unless the condensation cloud associated with that rotating column of air is touching the surface, it is not a tornado. This is manifestly untrue, as many storm chasers realize fully. Since it is the **wind** associated with the rotating air column that does the damage, it is the moving air (wind) and **not the cloud** that constitutes the tornado. Many tornadoes have been observed (Fig. 1 is but one of countless examples) that do not have condensation funnels all the way to the surface, but which clearly are in contact with the ground. It is quite possible for the circulation to be more or less completely invisible for at least some portion of the life cycle of the event. In the case of waterspouts (see below), this is frequently the case, but such events also occur in the dusty, dry mid-continental plains (Fig. 2). Chasers may refer to these events with such slang terms as "dust bowls" or "dirt-daubers."

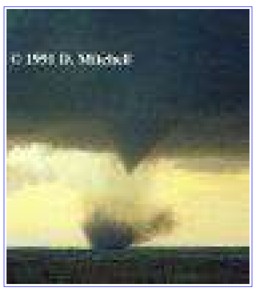

Fig. 1. Example of a tornado where the funnel does not reach the surface, on 15 May 1991, near Laverne, Oklahoma [photo ©1991 DeWayne Mitchell, used by permission].

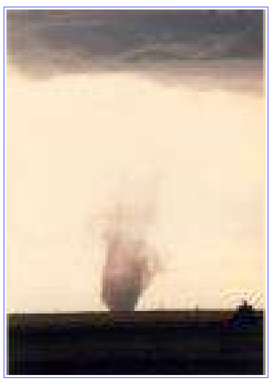

Fig. 2 Example of a tornado with no visible funnel, on 02 July 1987, near Denver, Colorado [photo

©1987 Bill Gallus, used by permission].

When the visible funnel does not reach the surface, silly reports of a "funnel cloud accompanied by wind damage" can occur, or such absurdities are reported as "The funnel only reached treetop level" or whatever. We probably will find it difficult ever to convince the public as a whole that a tornado is *wind* and not the funnel cloud. Hopefully, no self-respecting meteorologist would do anything to perpetuate such misconceptions. Also, storm chasers who believe this could get into a lot of trouble, quickly! By the way, "tornado on the ground" is redundant, since to **be** a tornado, the damaging winds have to be present at the surface at that time.

Many strong-to-violent tornadoes include a phase where the tornado appears as a truncated cone funnel (not reaching the surface) with occasional rope-like multiple vortices beneath it (e.g., the Xenia, Ohio tornado of 03 April 1974 or the Binger, Oklahoma tornado of 22 May 1981, Fig. 3). Lay persons might have considerable difficulty recognizing this for what it is, since it does not look like a "funnel-shaped cloud." Such an appearance, however, does **not** imply that one is in fact dealing with a strong-to-violent tornado ... **a tornado's appearance is not a reliable indicator of its intensity**, chaser lore notwithstanding.

Fig. 3. Binger, Oklahoma tornado of 22 May 1981, showing a truncated cone funnel with multiple vortices. [NSSL photo by Erik Rasmussen],

Among chasers, it is a common assumption that if a funnel cloud extends halfway or more to the ground from cloud base, there almost certainly is a tornadic circulation at the surface. This may or may not be true in any specific instance ... it probably is more right than wrong. For official purposes, however, such a "storm chaser's rule" is not a legitimate assumption; by definition, one must confirm the existence of a damaging circulation at the surface before the event can legitimately be called a tornado. If such a confirmation cannot be made, the event must be considered to be a funnel cloud or a "possible" tornado.

Recent research, some connected with the VORTEX program, has made it clear that vortical flows are often present at the surface, even without any visible funnel cloud. If a condensation funnel is present that does not "touch" the surface, some sort of "circulation" [10] is virtually certain to be present, but it may not be sufficient to raise debris. In the absence of debris, it is hard to know if the situation has become tornadic or not. I'll return to this later.

2. Waterspouts, landspouts, and ...?

Having mentioned waterspouts, this raises another topic. There is a special name for a tornado moving over the water: a waterspout. Why do we not have special names for tornadoes moving over sand (sandspout?), or asphalt (tarmacnado?), or mobile homes (manufacturnado?), or eucalyptus trees (gumswirl?)? Is it a waterspout if the water is fresh water rather than sea water? Does it become a waterspout if it moves over a lake? What about a pond? How about encountering a swimming pool or perhaps a puddle? How big does a body of water have to be to create a waterspout from a tornado? What about when crossing a river? A creek? A dry streambed? Would this last example be a "dry waterspout"? I am engaging deliberately in *reductio ad adsurdum* here because **I do not believe there is any scientific distinction of consequence between a waterspout and a tornado**!

In the new *Glossary*, in fact, the *definition* of a waterspout is now:

> **Waterspout** -- 1. In general, a **tornado** over a body of water. 2. In its most common form, a nonsupercell tornado over water.

For years, people believed that waterspouts were a distinctly different phenomenon, uniquely associated with tropical and subtropical convection that might not even qualify as cumulonimbus clouds. Of course, some "authorities" knew of the annoying problem of supercells over water; recognition of this produced the abominable term: "tornadic waterspout." Of late, it has been observed that phenomena quite comparable to waterspouts arise over the land, leading to another dubious term (that I have used!): "landspout" (by analogy, a "waterspoutic tornado"?). In my opinion, *all these terms refer to the same phenomenon*: an intense vortex associated with deep moist convection. Thus, I must quibble with the standard definition for its exclusion of convective vortices that happen with clouds not meeting the criteria to be cumulonimbi (e.g., those without glaciation at the cloud top).

I am proposing the following definition:

> **Tornado --** A vortex extending upward from the surface at least as far as cloud base (with that cloud base associated with deep moist convection), that is intense enough at the surface to do damage should be considered a tornado.

This is without regard to

- the underlying surface,
- the existence/non-existence of a condensation cloud from cloud base to the surface,
- the depth of the moist convective cloud,
- the presence/absence of ice in the upper reaches of the convective cloud,
- the occurrence/non-occurrence of lightning within the convective cloud, or even
- the intensity of the phenomenon beyond some lower threshold.

My broadened definition is designed to ignore what I consider to be incidental aspects of the situation. I believe that the physical process giving rise to an intense vortex is not associated with any of these coincidental issues and so the labeling of the real vortices that occur should not depend on them. It also excludes any phenomena not associated with deep moist convection, such as dust devils or "mountainadoes," and avoids making artificial and scientifically unjustified distinctions between "spouts" and tornadoes.[5]

I hasten to add that I do **not** believe that the physical processes giving rise to tornadoes are all the same. It appears that tornadoes arise in many different ways, and perhaps different process can be associated with the tornado at different times in its life cycle. Moreover, not all tornadoes associated with a given moist convective cloud arise via the same processes (see Doswell and Burgess 1993). Some of the relatively intense vortices associated with a convective storm probably should **not** be considered tornadoes; e.g., circulations not extending to the surface, and true gustnadoes (see below), assuming we can identify them as such. There is a fair amount of anecdotal evidence for non-tornadic intense vortices in association with convection (see Moller et al. 1974; Cooley 1978; Doswell 1985; Bluestein 1988; Doswell and Burgess 1993; Bluestein 1994), but not much hard information about the processes giving birth to these vortices.

At present, we are more or less content to classify tornadoes according to whether or not they occur with supercells. In the future, it may become scientifically useful to sub-classify tornadoes even further, as we learn more about how real events occur (as opposed to, say, events in our computer simulations!). If we must classify, then it seems to me that we should do so on the basis of physical processes and not be concerned with superficial aspects of the events. We are far enough along in our understanding of tornadoes that we ought to be able to move at levels deeper than the surface now.

3. Taxonomy problems [6]

Now, I wish to move into much more speculative and uncharted territory. For a tornado such as the famous Union City, Oklahoma tornado of 24 May 1973 (hereinafter referred to as "UC"), the life cycle of the event can be reasonably clear and understandable. The early stages with a rotating wall cloud give way to the development of a funnel cloud, then damage at the surface begins, followed by the descent of the funnel cloud to the ground. The width of the funnel increases to some maximum, and then begins to shrink, finally reaching a rope-like dissipation. The documentation for the UC event is extensive (see Brown 1976) and it might even be considered protoypical for many purposes. There is relatively little ambiguity in such events; there obviously is only the one tornadic vortex and its visual evolution can be inferred without much error from looking afterward at the evidence along the path. The UC damage path, surveyed extensively immediately after the storm, matches the visual images quite nicely. The visible funnel was more or less continuous until dissipation. The damage path coincides quite nicely with the visible vortex evolution. During dissipation, the visible funnel disappeared, but a clear debris cloud was still present for a few seconds longer at the surface.

All tornadoes are not this simple, however. The reality of tornadic events comprises a range of visible aspects that at times can be confusing and defies simple classification schemes. Multiple vortices introduce some complications. The UC event did not exhibit any obvious multi-vortex phase, but many tornadoes do. To some extent, the multi-vortex phenomenon is relatively well understood; the formal scientific literature on the subject (e.g., Snow 1978; Rotunno 1982; Gall 1985; Lewellen 1993) is fairly extensive. Whereas vortices like the UC event are "stable" in the sense that their visual aspect changes only slowly with time, other vortices are not so stable. The classic video from a helicopter in Minneapolis on 18 July 1986 illustrates the erratic, rapidly-changing visual structure of tornadoes having persistent multi-vortex behavior. Looked at from the perspective of a post-storm damage survey, however, the damage path in such a case might give a much more continuous "picture" of the event. Whereas the visual images are changing rapidly, the damaging winds at the surface can be more or less continuous, so if we did not have the video with which to compare, our damage survey might conclude with little doubt that a single tornado was involved, even though eyewitness accounts might well seem to contradict that rather vigorously. As scientists, we might smugly dismiss those eyewitness accounts with the observation that it probably was a multi-vortex event. For the Minneapolis event, all is well with such a dismissal; when visual evidence is present, perhaps we can afford to be smug. In the absence of visual documentation, I am rather less inclined to heap scorn on eyewitness accounts of odd behavior. I wasn't there, so I can't be certain what the eyewitnesses saw! [1]

After the 08 June 1974 tornado outbreak in Oklahoma and Kansas, I saw some 8 mm film (this was prior to the video age!) footage of a remarkable tornadic evolution; I believe it was a tornado near Luther, OK. I have been unable to relocate that footage, unfortunately. My memory of the film is that a quite distinct tornado (somewhat reminiscent of the UC funnel in shape, but with a lower cloud base) was moving along seemingly in a relatively stable fashion, when it seemed to dissipate suddenly and another similar funnel appeared rapidly right next to where the original funnel had been, all within about a second or two. The rapidity with which this remarkable transformation occurred was amazing to me. It seemed rather obvious to me that this visual record would almost certainly be the only clue that such an event occurred; now that record appears to be gone or at least unlocatable. The proximity of the two funnels virtually guaranteed that the damage path, as surveyed, would be viewed as continuous. Thus, if there were some slight offset in the damage path associated with the dissipation of one funnel and the development of the next, it almost certainly would not be evident to those doing a damage survey. To my knowledge, the tornado is classified as a single event. Perhaps this is a proper classification; perhaps this was simply a brief visual manifestation of a transient episode in the life of a single tornado. I raise the point simply because of the possible implications of that sudden transition.

Another, somewhat similar, episode has been documented by Davies et al. (1994) for the Hesston, Kansas tornado of 13 March 1990. In the Hesston storm, the visible funnel seemed to dissipate rapidly and re-form near the axis where it had been earlier but with a substantially smaller diameter, all within a brief time span. The question was asked, but not answered: Was this all a single tornado or could it be viewed as the dissipation of one tornado, followed by the nearly immediate development of another? Again, apparent continuity of the damage seems to leave this particular instance reasonably well-defined as a single event. Is it possible to conceive of such an event with a somewhat longer time span between the dissipation of one funnel and the development of another? I certainly have no trouble imagining something of that sort happening, such that a superficial examination of the damage path still might not detect such a gap. Not all damage surveys involve a thorough analysis of the path from start to end, both from the ground and from the air. Moreover, there might be several ways in which the illusion of a continuous damage track would appear even with a reasonably thorough survey. How big a gap in the path is enough to start considering the events to be separate? This brings me to the following discussion:

4. Do tornadoes "skip"? [7]

By the way, in most of my experience, tornadoes do not skip. Rather, they may weaken or intensify and thereby create gaps in the damage, but their continuity is relatively high. I have not heard a lot of storm chasers discussing how the tornadoes they observe "bounce" and "skip" across country. Gaps in the damage path can arise because (a) there is nothing to damage, or (b) the circulation has weakened to the extent that no evidence of the tornado's passage is left. Should we consider the latter to signify that the tornado "skipped" or "lifted" during an otherwise continuous track? Even more radically, would we say the cessation in damage constituted a cessation of the tornado? In many such cases, it is clear from film or video that a visible funnel and even a dust and debris whirl (albeit perhaps only small debris) is continuous even though "damage" is not occurring. In such a case, the damage path would give erroneous input to the classification of the event, often leading to the notion of "skipping" as a means of avoiding having each gap in an otherwise linear path represent a gap between individual tornadoes.

In footnote #7 (above), I proposed the following, slightly modified definition of a tornado:

> **Tornado --** A vortex extending upward from the surface at least as far as cloud base (with that cloud base associated with deep moist convection), that is intense enough at the surface to do damage at one or more points along its path, should be considered a tornado.

In some of these cases, it certainly can be argued that these are transient, superficial fluctuations in what might well be interpreted properly as a single event. A continuous, more or less linear damage path would be a compelling argument in favor of such an interpretation. However, the existence of multiple vortices, now a commonly-accepted variant of tornadic behavior, raises some troubling issues.

Furthermore, I have specifically *avoided* defining the windspeed at which "damage" begins (or ends!). The current windspeeds provided in the Fujita scale [see here (item #B.11) and here] indicate that F0 damage begins at 40 mph. That is not even a wind strong enough to qualify for a "severe" thunderstorm by operational standards (58 mph)! However, a 40 mph wind certainly would raise surface dust in, for example, many parts of West Texas! An observer must see "debris" at the surface if an event is to be considered a tornado, but this requirement is pretty nebulous. The ability to raise debris is, in a very real sense, dependent on the underlying surface and the conditions preceding the event. It's harder to raise dust on a muddy field than a dry one. We are unlikely ever to be able to obtain windspeed measurements associated with the surface circulations in real time (i.e., as an observer watches the event), so it seems fruitless to establish windspeed criteria in the definition. The only value it might have would be in the abstract, or for the unforeseen future, where it *might* someday be possible to get detailed windspeed measurements. If I were pressed to provide a threshold, I'd say that the minimum tornadic windspeed should be 58 mph (50 kts or about 25 m s^{-1}), which is the current threshold used for "straightline" winds in thunderstorms.

For clearly damaging tornadoes with prominent condensation funnels, etc., there is little ambiguity. It's only on the margins of the definition that we have problems (although that seems to be a common problem with *any* definition, as this essay, overall, is suggesting). The ambiguity of what winds are capable of producing "damage" clearly feeds into the problem of "skipping" tornadoes, of course.

Let me digress for a moment, to establish some more background.

5. Another brief digression

Atmospheric vortices form a spectrum, in my opinion, with no clear boundaries **kinematically** between events. That is, atmospheric flow can be organized into vortices of essentially **any** size. The fact that there are **preferred** sizes often reflects the existence of the dominance of some physical instability that has a characteristic scale length (e.g., baroclinic instability). Thus, vortices can be classified according to the **physical processes** that give them birth, but there is no compelling reason for classifying vortices solely on the basis of their **size**. Hence, the boundaries among events have an obvious tendency to be quite "fuzzy." We think we know, for instance, the characteristic scale size of an extratropical cyclone. We also know that cyclonic storms exist which we consider to be "distinct" in some way (typically size is a factor in making such distinctions) from extratropical cyclones; polar lows or tropical cyclones to name two. Nevertheless, there are times when polar lows or even tropical cyclones seem to have a decidedly baroclinic aspect and one can get into intense arguments about where any particular event fits in a taxonomy of cyclones. It seems that even on synoptic scales, there is room for debate over classifications.

If we put a particular event into a particular bin, we tend to apply a set of default assumptions about the character of such an event. This can be the source for considerable confusion at times, as I have tried to indicate in a comment about a particular classification scheme (Doswell 1991). Classification does not seem to be a very important aspect of science to some, but it affects the way we view the real world. In effect, putting an event into a "bin" seems to imply all sorts of things about that event which may not be valid for the particular instance.

6. Possibilities and observations

Having put up with this preamble, indulge me for a bit more. I am going to describe a pot pourri of events that (a) I have witnessed directly in storm chasing, or (b) have had described to me (perhaps with images) by fellow storm chasers, (c) I have seen in film and video of events, or (d) are reasonable extrapolations of things unobserved but which *could* be observed and yet not be documented as such.

a. Mesocyclones[2]. A characteristic of mesocyclones is that they represent a perturbation flow that is roughly the same size as the updraft region of a cumulonimbus. Although cumulonimbus clouds do not cover a huge range of sizes, neither are they all the same size. Thus, mesocyclones almost necessarily have a range of sizes, mostly on the order of a few km in diameter; as opposed to a few tens of km in diameter or a few hundred m in diameter. Moreover, mesocyclones have a range of intensities, with the intensity usually measured in terms of shear or vorticity. Arguably, another measure of intensity could be the **maximum** windspeed anywhere within the mesocyclonic circulation (the boundaries of which might be a bit tough to define, if pressed). Some mesocyclones, perhaps even some on the lower end of the size range, could easily be associated with windspeed maxima in a range where damage would result if they interact with the surface. Such an event, if it occurs in the real world, meets the definition of a tornado I quoted earlier! That is, it is a violently rotating column of air in association with a deep convective cloud and is in contact with the surface of the earth. Such events could even have cloud material right down to the surface in the right environment, manifesting themselves as a wide tornado.

b. Multiple-vortex mesocyclones. Gene Moore (a reasonably well-known and highly respected storm chaser) once showed me photographs of an amazing event he witnessed in the Texas Panhandle. It involved a large rotating wall cloud, apparently several km in diameter. From time to time, a funnel cloud would form, producing what appeared to be a slender, ropy tornado around the periphery of this wall cloud. The funnel cloud typically would extend to the surface briefly and then dissipate, to be followed a few minutes thereafter by another such event elsewhere on the wall cloud's periphery. Apparently, this went on for some time. Is each such event an individual tornado, or are they simply vortices embedded within a single multi-vortex tornado with intensity fluctuations? If one were to look at the damage carefully, it is not entirely clear that a single damage path would be involved. The damage might appear to be quite chaotic, given the vagaries of the associated events and the likelihood of a damaging event interacting with something (trees and structures are pretty sparse in the Texas panhandle) to mark the event. Short streaks of damage might have various orientations and could appear rather erratic. Without visual documentation, it might be possible to do a damage survey and conclude that what had happened was a series of microbursts. A rather well-respected survey team (which will remain anonymous) overflew the track of a documented tornado on 10 April 1979 near Seymour, Texas and concluded it was a downburst, so I have reason to believe that a damage survey is not necessarily definitive!

Given a mesocyclone, who is to say that they are all dynamically stable, slowly-evolving phenomena? A mesocyclone might well manifest the same multi-vortex complexity that virtually all vortices exhibit, resulting in a miniature tornado "outbreak" of a sort (as described by Snow and Agee 1975). Suppose there was a fairly regular production of such events associated with a moving storm, at intervals in space and time. Such a case would appear as a tornado "family" associated with a traveling supercell (the Fargo events of 20 June 1957 are the prototypical example, as documented by Fujita 1960). For such a case we have universally chosen to accept them as separate tornadoes, but it might be argued that they really are simply manifestations of a single event: a long-lived mesocyclone with embedded multiple vortices. How might one draw the line here? Is it so hard to imagine situations where classification might prove troublesome? What about a small, intense mesocyclone in a high-humidity environment? Such an event might have a nearly continuous lowering and spotty damage, with subvortices that could be considered tornadoes or tornado cyclones. How large (small) and intense (weak) can a tornado (tornado cyclone, mesocyclone) be? Where do *you* propose to put the dividing lines between tornado-tornado cyclone-mesocyclone?

c. Large, multiple-vortex events. I have seen video (in Tornado Video Classics III) of another amazing event in the Texas Panhandle, near Lazbuddie on 10 May 1991. This event apparently involved a relatively large tornado (on the order of a UC funnel) at the center of a ring of smaller tornadic vortices. The central funnel was more persistent than the surrounding ones, with several funnel clouds in contact with the surface simultaneously from time to time. Is each funnel in such an event a single tornado, or is the whole collection simply a manifestation of a single tornadic event, with multiple vortices? Is it one tornado within a multivortex mesocyclone? How does one classify such a mess? Presumably, these are rare events, but exactly how many tornadoes should be recorded for that event?

d. Tornado cyclones. During the Pampa, Texas tornado I was privileged to witness on 08 June 1995, a fascinating evolution occurred. The tornado I will call the "first" tornado began as a ragged, rotating lowering that produced several brief episodes of dust whirls and small debris at the surface, apparently out in open country southeast of Pampa. During that same time, low-level, multiple-vortex funnels appeared and then disappeared within a few seconds on several occasions. Following this, the tornado seemed to become very disorganized, with a new area of rotation developing as a clear slot wrapped around a truncated, cone-shaped funnel near where the original rotation became disorganized. This second area evolved into a very "stable" tornado. As this was happening, another funnel was developing to the northeast of the event we were watching, which I will call the "third" tornado. The interaction of these two cyclones was odd in that the second tornado (southwest of the developing third tornado the whole time) initially moved westward, then northward, and finally northeastward, whereas the third tornado (developing rapidly as the second one was dissipating) apparently moved mainly northward. Was the first series of brief debris whirls and occasional multiple-vortex funnels (without a complete connection to cloud base) a separate event from the event that finally moved through western Pampa? Or was it all a single tornado? Were there two mesocyclones or were we seeing separate "tornado cyclones" within a single mesocyclone? Perhaps the data available will permit answers .. but perhaps not. In most cases, of course, high-resolution data and videotapes of the event would not be available. These details are simply lost for most events.

e. Other wierd things. It is plausible to believe that gustnadoes can develop into tornadoes (see below); there are at least some indications [e.g., from Erik Rasmussen in some personal communications] that a true dust devil could, as well! Essentially, there are many ways to produce an intense vortex from a preexisting, nontornadic vortex. Since there's a lot we don't know or understand, if we look carefully, we may continue to find examples that don't fit our nice, clean hypotheses.[8]

The events I have been describing above and others, some mentioned in the reviewed literature (Doswell and Burgess 1993, Davies et al. 1994, Forbes and Wakimoto 1983, etc.) and some not, all make me concerned for what we have recorded as tornadoes in the historical record. For example, insofar as that record is concerned, the Tri-State tornado is a single tornado event. As already discussed elsewhere (Doswell and Burgess 1988), there is room for debate about whether or not this actually was a single event. Continuity of the damage path is, as I have suggested, not entirely convincing that a single tornado was involved. Of course, I am even questioning whether a tornado "family" of the sort that **might** be involved with the Tri-State event is really more than one event. In other words, I am not taking a dogmatic position here ... I am willing and eager to consider other views, but what concerns me is that (a) we have the debate, and (b) we reach some consensus about how to record the real events.

7. Struggling toward a definition

The growth of scientific understanding about tornadoes does not mean that clarity of insight follows immediately. As noted, I feel somewhat concerned about our concepts of tornadogenesis. A tornado (as I am fond of saying), irrespective of the details of the definition, is not an **object**; it is a **process**. That is, the wind field that we define to be the tornado exists as a result of, and evolves in response to, other processes. Observationally, it seems that vortices of this intensity are produced virtually exclusively in association with deep moist convection. There surely are dust devils (dry convective vortices) that attain damaging proportions but they are uncommon and we know essentially nothing about their distribution. Since the strongest dust devils probably occur in arid regions of extremely sparse population, our ignorance of such events is large.

Within the range of vortices associated with deep moist convection, I suspect that a lot of different processes can produce vortices in convective clouds, very few of which affect the surface. There is some limited mention of such events in the literature (Moller et al. 1974; Cooley 1978; Doswell 1985 [p. 107]; Bluestein 1988; Doswell and Burgess 1993; Bluestein 1994; etc.). For example, Cooley's paper is the only mention of "cold air funnels" in the refereed journals. At times, I have heard of funnels being tagged by forecasters as "cold air funnels" in situations quite radically different from the prototype described by Cooley and discussed briefly in Doswell and Burgess (1993). An erroneous classification of such vortices might be prompted by a perceived need to "explain" surprise observations of funnels, but it probably does more harm than good to provide a *bad* explanation. Unfortunately, science can offer little more than speculation about the origins of these non-tornadic vortices (e.g., Bluestein 1994). It is conceivable that some tiny percentage of these minor events (examples shown in Fig. 4 and Fig. 5) could produce damaging winds at the surface, but I have no way of knowing what that percentage might be, nor by what processes such vortices might come to reach damaging intensity at the surface, to say nothing of their origins.

Fig. 4. Example of a non-tornadic vortex seen on the northwest flank of the UC storm on 24 May 1973 [photo ©1973 by Chuck Doswell], as discussed in Moller et al. 1974.

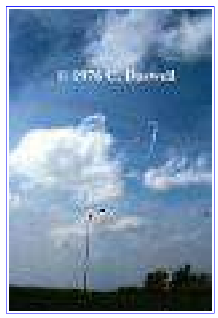

Fig. 5. Example of a non-tornadic vortex associated with a dissipating cumulus cloud on 13 April 1976, near Shamrock, Texas [photo ©1976 by Chuck Doswell]. These are sometimes referred to by chasers as "horseshoe" funnels.

Events that we might reasonably call tornadoes appear to be associated with:

- the mesocyclone (in supercells),
- low-level boundaries produced by the convective storm,
- low-level boundaries *not* produced by the convection but which interact with the convection.

As noted in Davies-Jones and Brooks (1993) and discussed in another essay of mine, the issue with a tornado is to get the high vorticity near to the surface. It appears that processes associated with the mesocyclone and low-level boundaries are likely candidates for obtaining tornadic vorticity at the surface. I note that a supercell (in my opinion) need only have a mesocyclonic circulation meeting certain criteria (see Doswell 1996) to qualify as a supercell and that the mesocyclone need not be present at low levels. (Other views exist; see, e.g., Droegemeier et al. 1996.) Low-level mesocyclones are apparently the result of different processes than those that produce mid-level mesocyclones (see Brooks et al. 1994). At this time, it is unclear what percentage of low-level mesocyclones produce tornadoes, but apparently fewer than 50 percent of those storms having mesocyclones at any level produce tornadoes. [Note added on 26 June

`1998: this percentage might be as low as 10 percent!]`

In the case of "landspouts," it seems that pre-existing vortices along pre-existing low-level boundaries might "explain" tornadogenesis. With those tornadoes that seem to form aloft and descend (the TVS - see Trapp and Davies-Jones 1996), the story may be complex dynamically, and involve an interaction between the updraft and its own rain-cooled outflow. It also could be that real events involve a complex mixture of all three processes [(a)-(c), above] at times. Whatever we find out about these processes in the real world, it almost certainly is going to be the case that there is no single path to a tornado, even when we restrict our attention to those events that are clearly and unambiguously tornadoes (*Including* landspouts ... **landspouts are tornadoes**, by any reasonable definition of a tornado. Like the waterspout, I'd prefer not having a specific term for this kind of event, since it only seems to create confusion.). Not all significant tornadoes are the same, even though their flow fields might end up looking alike ... a vortex after all, has a certain characteristic kinematic structure irrespective of the processes that produced it.

8. What to do with "gustnadoes"?

There is another class of events that has caused a large amount of heartburn: **gustnadoes**. Observations indicate clearly that relatively weak, short-lived vortices can form along the leading edge of an outflow boundary. The mechanism(s) by which such vortices form? No one really knows. Hence, almost anything I can say about these events is pure speculation. We have no detailed Doppler radar observations of them; we have no numerical simulations of them; we have virtually no validated knowledge. All we have is anecdotal evidence from storm chasing and some analogies with things seen in laboratory simulations (Idso 1975). The visual appearances of true gustnadoes (as opposed to tornadoes along a gust front, which are manifestly different phenomena) indicate they are shallow (perhaps 10-100 m deep) with no apparent connection to any process happening at cloud base or above (Fig. 6). When they arise, which I believe to be frequently, they occur in "swarms" such that there may be several in existence at the same time along the same gust front, forming and dissipating within no more than a few minutes and probably having only weak wind perturbations. Superimposed on a damaging gust front (i.e., a downburst), they might represent local concentrations of damage. Superimposed on a non-damaging gust front, they might be manifest as isolated damage events in an otherwise benign situation. My guess is that typically, they represent only a minor perturbation of essentially no significance, except in very rare examples.

Fig. 6. One of several gustnado events near Welch, Texas on 23 May 1982 [photo ©1982 by Chuck

Doswell].

I have some anecdotal evidence that a gustnado can evolve into a true tornado [Dave Blanchard, personal communication], but such an evolution is almost certainly rare. Whereas some true tornadoes might initially resemble a gustnado at the start, **I certainly would find it easy to deny gustnadoes (as I have defined them) the status of true tornadoes**. Unfortunately, it may be hard to train folks to be able to distinguish them from other vortices occurring in conjunction with deep, moist convection. I certainly have encountered a lot of different notions about gustnadoes, even among meteorologists, much less the lay public. There seems to be a disturbing trend to refer to all tornadoes occurring on a gust front as "gustnadoes" whereas I have tried, apparently without success, to confine the term to the *shallow* vortices on gust fronts that seem not to extend as far as cloud base. Moreover, even with 20+ years of chasing behind me, I still am encountering things I haven't seen before. What about the person experiencing something like this for the first time? If that person is confused and has a hard time sorting out what he/she experienced, I think they can be forgiven. But we need not assume that the public is congenitally stupid, either. Some people can report quite accurately what they saw, but they describe it in inappropriate terms (e.g., a tornado with multiple vortices becomes several tornadoes merging into one)

There is a lot we don't know about what happens along seemingly boring, 2-dimensional gust fronts! Perhaps gust fronts are prone to dynamical instabilities on a variety of scales, some of which remain small (gustnadoes), some of which are large and persistent enough ("misoscale" eddies) to become a bona fide tornado. There might be a whole spectrum of structures along gust fronts, many of which do not attain "tornadic" proportions (however we might choose to define a tornado). If that is the case, then it might be quite difficult to anticipate when a gust front would produce damaging vortices, from gustnadoes on up to and including what would unambiguously be called tornadoes. The topic of what might happen along gust fronts was written about by Idso (1974; 1975) in a very speculative vein, but little of substance has been done with the topic.

9. Cold air funnels

This topic never seems to go away for long, so I suppose I should say just a *little* more about cold air funnels. There is not much about them in the literature ... the only published paper about them of which I am aware is that by Cooley (1978) and it offers relatively little insight. Doswell and Burgess (1993) have discussed them, but not in depth, because little of depth can be said. They occur in association with convective clouds (that may have little or no thunder) developing within cold pools aloft, in environments with relatively little vertical wind shear. These should be distinguished from tornadoes with low-topped supercells (that typically arise in environments that may be notably cold aloft, but with considerable vertical wind shear) and from "landspout"-type events (that have relatively little vertical wind shear, but are not tied to cold pools aloft). Cold air funnels are *not* items for urgent study because of their lack of associated damage and casualties ... we have other things to worry about that really do damage and create casualties. In my experience, many events are labeled inappropriately as "cold air funnels" even when they are not associated directly with cold pools aloft, simply because the events are unexplained (as noted in section 7, above). If one of these should happen to do surface damage, then I see it as a tornado ... plain and simple.

10. Horizontal homogeneity?

If we admit that pre-existing boundaries often interact with the convection and that the interaction might be very important in tornadogenesis, the picture becomes quite complex, perhaps intimidatingly so. Sometimes the interaction seems to favor tornadogenesis, while at other times, it seems to preclude tornadogenesis. Not every boundary with which a storm might interact is the same. Nor does the interaction have to follow precisely the same course every time even when the boundaries are nearly identical; perhaps there are many factors (age of the storm, its movement relative to the boundary, its orientation relative to the boundary, etc.) that could alter the course of the interaction. In this arena, we are abysmally ignorant at the moment. We have only very rudimentary knowledge of these interactions. It appears that boundaries of all sorts exist in abundance in "clear" air and may only show up occasionally on satellites as cloud lines. Some of them appear on high-sensitivity radars (like the WSR-88D) but we know next to nothing about them ... their origins, structure, and evolution are open topics for speculation, especially operationally.

There is evidence to suggest that even supercells on "synoptically evident" tornado outbreak days do not necessarily produce tornadoes via some self-contained "cascade" process. Davies et al (1994) suggested that the Hesston tornado family may have involved an interaction with a pre-existing boundary. Jim Purdom has been saying similar things for years (e.g., Purdom and Sinclair 1988) about many storms on outbreak days. At this point, the numerical storm simulations (virtually all initiated with horizontally homogeneous initial conditions) suggest that such interactions are not necessary. Nevertheless, **real** storms have a disturbing proclivity to produce tornadoes in association with interactions involving pre-existing horizontal inhomogeneities. It might be that we simply cannot understand tornadogenesis properly without including inhomogeneous initial conditions in our numerical simulations; see my essay on post-VORTEX thoughts. Given the bewildering nature of such interactions with the variety of boundaries that seem to be showing up in our new, high-resolution observations, it is going to be a challenging time to follow the thread of tornadogenesis. It could be some time before we can establish common characteristics and begin to see order in the apparent chaos. It seems to me that in order to accomplish that future orderly synthesis, we are ill-served by a taxonomy (classification scheme) that fails to distinguish tornadoes by the relevant physical processes.

11. A tornado database

Unfortunately, since we do not **know** (in a completely satisfactory way, at least) what are the relevant physical processes, we are caught in a bit of a "Catch-22" conundrum: to understand tornadoes, we need a proper classification ... but to develop a proper classification, we need to understand tornadoes! I am confident we eventually can work our way out of this seeming paradox, but it will involve small incremental steps, first learning something about tornadoes and then applying that to the classification. Perhaps the prior classifications cannot be salvaged without information about particular events that, if we ever had it, has been lost over time. The tornado data base should be modified regularly to contain the information needed to classify the events as best we know how at any given time. Keeping continuity with the past is of little value if by doing so we miss the chance to gain a better understanding. Better to change the record-keeping frequently as we develop better understanding .. we always can "degrade" high-quality data to look like low-quality data if consistency is the goal, but the reverse usually is not possible. My colleague, Erik Rasmussen has proposed an interesting idea for a new database for folks to consider.

The day of having a simple collection of "tornado events" ought to be put behind us soon, if we are ever to gain a deeper understanding of the processes. We must expand our data base to include information about the storm that produced the event: was it a supercell (using whatever definition we can arrive at as a consensus)? Was it a developing cloud or was it a mature storm? Was it interacting with a detectable boundary? What is (are) the source(s) for information about the event? If assessments are quantitative, what data were used and how were thresholds defined? If assessments are subjective, what is their factual basis? And so on.[3] We also must begin to make some sort of distinctions among tornadoes, perhaps gropingly at first. Is the tornado "stable" in the visual sense I have described? Are there any gaps or irregularities in the damage path and what is the nature of those irregularities? Was the tornado pendant from a wall cloud? What was the location of the event relative to the mesocyclone, if a mesocyclone was associated with the storm (and what is the operative definition of a mesocyclone?)? Does the event fit any of the recognized categories of convective vortices (whatever those categories might be at the time)? Did it have any distinctive characteristics (e.g., no visible funnel, multiple vortices, smooth and laminar, ragged and turbulent, very wide, dramatic changes in its characteristics during its life cycle, etc.)?

I realize fully that this is asking for a **lot** of information relative to where we are now. However, it seems to me that a "tornado database" that does not ask for a lot of information about tornadoes is not going to have much to offer, except perhaps to actuaries for the insurance companies, who aren't concerned with scientific subtleties.

12. Recognition of tornadic damage

Neil Stuart (presently at the Wakefield, VA office of the National Weather Service) has raised some interesting points via e-mail correspondence. In some cases, there is very strong horizontal wind shear in storms (even tropical cyclones) ... the wind speeds associated with such wind shear can attain damaging values and so create damage paths. Obviously, this is true for thunderstorms, since they produce strong outflows (often called downbursts). Along the flanks of a downburst, strong horizontal gradients of the wind can be found, and such shears can be associated with substantial vorticity (both cyclonic and anticyclonic). In theory, such "sheets" of horizontal wind shear are unstable and should "roll up" (Fig. 7) into a series of discrete vortices; in the process, the shear line's vorticity (originally spread out along the line) becomes concentrated into a number of vortices.

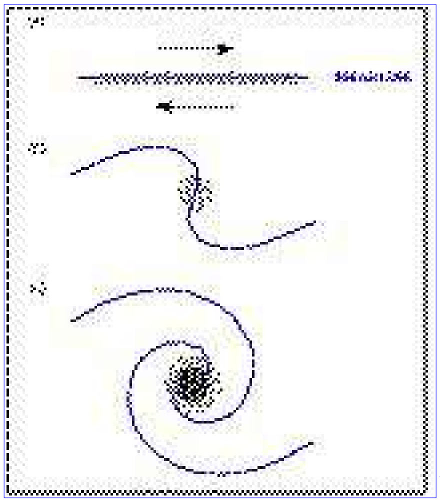 Fig.7

Fig. 7. A schematic look at the "roll up" of a vortex sheet, where the shear line at the surface reflects a vertical *sheet* of vorticity. In (a), the vorticity (stippling) is spread out along the shear line; in (b) and (c), the vorticity becomes increasingly concentrated into discrete vorticity centers as the roll up proceeds. In this example, the sense of the vorticity is associated with a clockwise vortex, but the argument is independent of the sign of the vorticity.

Thus, if strong vorticity spread out along a line is present at some moment, it is likely that it will break down into a string of separate vorticity centers. This might have relevance for the origin of gustnadoes, and has been proposed for tornadoes as well (although tornadoes are more complex because it seems not all tornadoes develop in the same way). However, the notion that high vorticity tends to evolve into compact centers rather than being strung out along a line is relevant.

As discussed in my vorticity primer, the issue of whether or not a vortex (i.e., a compact region of vorticity) produces a closed flow depends in part on the reference frame. If a moderately intense vorticity center is moving relatively rapidly, the ground-relative flow may not be a closed vortex. In fact, many weak to moderate tornadoes that move rapidly have damaging winds only on one side of the vortex. This produces a damage path that contains little or no direct evidence of rotation ... all the damage may appear to be coming from more or less the same direction. This can lead some investigators to conclude that the event was not a tornado, but rather a microburst. The giveaway, however, is the existence of a *long, narrow damage path* . As the center of high vorticity moves along, it creates a narrow swath of damage.

If the damage is done by a moving center of high vorticity, resulting in a damage path that is narrow relative to its length, I am inclined to call it a tornado (or a gustnado, depending on the circumstances). I am not inclined to reject the tornado hypothesis simply because the damage is unidirectional, for reasons just given. That is, it is not obvious to me that the flow *must* be closed in a ground-relative sense for the event to be considered a tornado. If there are Doppler radar data, the *storm-relative* framework often will show a fair amount of symmetry in a vortex flow, even if the ground-relative flow is highly asymmetric.

A downburst (or microburst) creates a difluent damage path, because the winds are forced to spread apart as they interact with the solid ground ... the resulting divergence creates a fan-shaped damage region that may start out concentrated but rapidly spreads out and weakens. This is quite different from the damage produced by a concentrated vorticity center moving along.

On the other hand, people often are heard saying that such things as twisted trees, street signs, and other "indicators of rotation" imply that an event was a tornado. The scale of rotation in tornadoes is on the order of hundreds of meters, generally. A twisted tree can arise from purely straight-line winds if the tree's resistance to the wind is not symmetric, for example ... that is, the tree yields to the wind in a asymmetric fashion. Those doing damage surveys need to be aware of this all-too-common misunderstanding of the scale of tornadic vorticity; it usually is much larger than the structures and objects that are damaged, so *on the scale of the structures* , the damaging winds are "straight."[9]

13. Observational Meteorology

As a final footnote to all of this, it seems to me that VORTEX has underscored the relevance and value of observational programs. We have seen enough from the observations to cast real doubt on most of what we thought we knew. There have been those who considered the theory and numerical simulations to be so far advanced that observations could serve only to confirm the theoretical and numerical findings. In my opinion, VORTEX has invalidated this view, as described in my other VORTEX-related essay; the observations have shown the inadequacies and shortcomings of these approaches quite clearly. Moreover, the new data sets are revealing a host of new phenomena about which we know virtually nothing. The relevance of these new phenomena to tornadogenesis has yet to be shown, but it should be noted that we cannot rule them out *a priori* as important factors, either. It appears that observational meteorology is in need of some support; shutting down our observational programs in favor of theory and numerical simulations would be a scientific tragedy (and travesty!!) for us all. Theory, modeling, and observations each have their own roles to play in science, and we cannot do without any one of them. Observational meteorology has been given far too little attention and value over the past two decades. Decreasing budgets have resulted in a disproportionate share of the burden has falling on observational facilities. I believe that VORTEX contains a message: the community should recognize that theory and modeling are not by themselves sufficient to carry our science.

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Eliminating Microorganisms from Water

Adding chlorine to drinking water has virtually eliminated waterborne diseases such as cholera in North America by destroying disease-causing microorganisms. You can safely and easily demonstrate how chlorine protects public health by removing microscopic life from a water culture that you create.

Materials

- Tap or fresh water (untreated water will yield more microorganisms)
- Wide-mouth glass vessel that holds about a quart of water (e.g., Mason jar) and several smaller glass vessels
- Container and heat source to boil water Handful of dry hay or straw (dry, untreated grass will do)
- Microscope (minimum 100 power)
- Glass slides
- Liquid laundry bleach (5.25% sodium hypochlorite)
- Measuring cup
- Eyedropper
- Plastic stirrer
- Thin rubber gloves
- Safety goggles or glasses
- Paper towels

Safety

Wear rubber gloves during the experiment. Do not allow culture to contact your body (people with cuts should not touch the culture).

Follow all label directions on bleach (it will bleach clothing).

Keep hands away from face during the experiment. Wear safety goggles/glasses when handling the bleach.

Thoroughly clean all equipment, gloves and hands when finished

Dispose of the culture in the toilet. Dispose of bleach solution in sink followed by a five-minute flush with cold water, and dispose of other materials in a clean trash bag.

Procedure

1. Boil about one quart of water (tap or freshwater) for two minutes, let cool to room temperature, and pour into a thoroughly clean, wide-mouth glass vessel.

Put a handful of dry hay, straw or grass into the vessel and set it aside in a darkened place at room temperature for seven to nine days. You are creating a water culture that will teem with microscopic life.

2. After the wait, place a glass slide on the microscope and use the eyedropper to put a drop of the water culture on the slide. (Place a cover slip on the water culture drop). You and your students will be able to view many microscopic life forms, including protozoa (amoebas, parameciums) and nematodes (microscopic worms) moving around. These are the same types of organisms which live in surface waters and are removed during the water-chlorination process. In fact, certain protozoa are responsible for amoebic dysentery and giardia, which are common illnesses associated with water that is not properly chlorinated. Use several slides to sample water and view life forms from different parts of the culture.

3. Now pour about one cup (eight ounces) of the water culture (being careful not to spill) into another clean container. Make up a solution of one part bleach to nine parts water in another container. After stirring the solution and rinsing the eyedropper, place about 20 drops of bleach solution into the cup of water culture; stir the water culture/bleach solution and let sit for about one minute. Thoroughly rinse the eyedropper in tap water and examine several drops of the bleach-treated culture. You should see no animals still alive in the water.

Suggestion

Arrange a field trip for your class to the local water treatment facility to learn where tap water comes from and why water disinfection and source water protection are important. Discuss tradeoffs involved (e.g., disinfection by-products vs. microbial contamination).

Instructor's Notes

If microscopes are not available, use pond water and add chemical fertilizer and set in direct sunlight, allowing eutrophication to take place.

PhysicalGeography.net | WELCOME

Welcome to PhysicalGeography.net

PhysicalGeography.net is an educational web portal that focuses on a specific area knowledge known as **Physical Geography**. Physical Geography is a sub-discipline of two much larger fields of study - Geography and Earth Sciences. The main purpose of Physical Geography is to explain the spatial characteristics of the various natural phenomena that exist in Earth's hydrosphere, biosphere, atmosphere, and lithosphere.

Another great online learning resource dealing with Physical Geography has been created by Michael Ritter of University of Wisconsin - Stevens Point. This online textbook is called **The Physical Environment: An Introduction to Physical Geography**. I highly recommend it.

If you would like to learn more about how **PhysicalGeography.net** is structured please select the "**About**" link above.

I hope you enjoy the site!

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Educating Young People About Water

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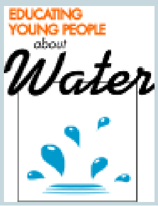

Educating Young People About Water (EYPAW) guides and water curricula database provide assistance for developing a community-based, youth water education program. These resources target youth and link educators to key community members to build partnerships to meet common water education goals. EYPAW materials will help you:

- Choose water curricula appropriate for learners.
- Plan and evaluate a water education program in relation to a local water issue.
- Work in partnership with local experts.
- Improve youth's ability to manage and protect water.

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Contents of each Acrobat file:

PDF File Name	File Size	Contents
planeval.pdf	479 kb	whole guide
pecover.pdf	215 kb	cover
pdfintro.pdf	245 kb	Introduction to A Guide to Program Planning and Evaluation What do we know about youth water education programs? Curriculum and programming gaps Successful program features Successful programming strategies
peresrc.pdf	379 kb	Setting up a successful water education program Key elements of a successful water education program A sense of place, stewardship, and community action Planning and evaluating for success Planning Evaluating Using the checklists Using the resources Managing for success: the role of the "instigator"
11-16.pdf	144 kb	Water Program Planning Checklist Who should use this checklist? How to use the checklist 1. Program planning overview/review 2. Assessing community water education needs 3. Identifying networks and partners
17-21.pdf	138 kb	4. Reviewing organizational support 5. Determining goals and objectives
22-26.pdf	135 kb	6. Designing your program
27-31.pdf	131 kb	7. Choosing a program delivery strategy 8. Evaluating your program

32-37.pdf	176 kb	Water Program Evaluation Checklist Who should use this checklist? How to use this checklist 1. Looking at your results overview/summary 2. Organization mission 3. Why do this program?
38-42.pdf	139 kb	4. Program support, partners and networks 5. Program goals,design and access
43-47.pdf	139 kb	6. Program delivery 7. Evaluation Resources

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Contents of each Acrobat file:

PDF File Name	File Size	Contents
unique.pdf	781k	whole guide
a-20.pdf	391k	Youth water education: an overview Nonformal education settings Program size and scope Common goals Identifying water programs Selecting unique programs How to use this guide Using other resources Directory of programs Campaigns Clubs Community service learning Day camps and summer education programs Festivals and fairs Museums Nature centers and environmental education centers Organizations Residential camps School enrichment Program profiles
21-40.pdf	160 KB	Program profiles
41-60.pdf	206 KB	Appendices: Appendix A Definitions of nonformal youth water education settings Appendix B Water education topics cross-referenced with water education programs Appendix C Program Profile Form for reporting unique program design and delivery
61-66.pdf	53.5 KB	Appendix D References for youth development skills

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Contents of each Acrobat file:

PDF File Name	File Size
Whole Guide	479k
Cover-page 20	262k
pages 21-40	158k
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Contents

GROUND WATER

NEW Ground Water Protection Regulation (GWPR)

- Backgrounder (HTML)
- Regulation (PDF: 37 pages / 3.72 MB)

The GWPR deals with aspects of well construction that significantly enhance ground water protection i.e., installing effective surface seals around wells, securely capping and floodproofing wells, and permanently closing unused wells to protect ground water quality. The GWPR also establishes the qualifications for well drillers and well pump installers and provides for a provincial registry of those possessing the qualifications.

NEW Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Ground Water

PDF: 54 pages / 1.4 MB

This guide is designed to help readers interpret and use the aquifer classification maps produced by the Ministry of Water, Land and Air Protection.

NEW Linking Water Science to Policy: Ground Water Quality
(CCME site)
A workshop sponsored by the Canadian Council of Ministers of the Environment.

PDF: 69 pages

Fact Sheets about Ground Water Quality
These seven fact sheets provide general information on total and faecal coliform bacteria; nitrate; arsenic; fluoride; sodium; iron and manganese; and hardness and their main occurrence in the province.

Frequently Asked Questions (FAQs): Water Wells ... and Well Water Quality

Canadian Framework for Collaboration on Ground Water

• Top

Ground Water Resources of BC
This publication provides an overview of the ground water resources of British Columbia; how ground water occurs, where it is found and what conditions favour

- " MTBE in Ground Water PDF: 105 KB / 2 pages
- " Observation Wells
- " Observation Well Network (how it works)
- " Reference Library
- " Schedule of Charges and Service Requests
- " Quality Standards for Drinking Water
- " Water Well Records
- " Well Database
- " Well Data Capture
- " Well Protection Toolkit

Other Links

- " Drinking Water Program (Ministry of Health Services)
- " Freshwater (Environment Canada)
- " Ground Water (Environment Canada)
- " Canadian Ground Water Association
- " The British Columbia Ground Water Association
- " Land and Resource Registries Portal
- " International Ground Water Resources Assessment Centre
- " More Ground Water Related Links

its development for social and economic benefits. See also Practical Information on Ground Water Development.

Aquifers and Water Wells in BC
This interface to ground water aquifers and water well locations is under development, and now replaces other methods of delivering ground water data to the public, consultants and water well drillers. Hard copies of water well location mapping are no longer available, as this service has been replaced by Aquifers and Water Wells in BC.

Current Ground Water Conditions in British Columbia: through selected observation wells.

Below are links to two historical guidelines documents for construction, testing, maintenance, alteration and closure of wells in British Columbia. When the Ground Water Protection Regulation (GWPR) takes effect, the standards in the GWPR will supersede the guidelines in these historical documents. The two historical guidelines documents may still be useful, particularly for items which the GWPR currently does not cover. Where there are any differences between the standards in the GWPR and the guidelines in the historical documents, those outlined in the GWPR take precedence.

DRAFT Code of Practice for Construction, Testing, Maintenance and Closure of Wells

Guidelines for Minimum Standards in Water Well Construction

· Top

The Well Drilling Data Capture System
(Ground water Data Management, Version 1b)
The Well Drilling Data Capture System has been designed to provide water well drillers with an easy to use customizable database that is compatible with the database systems used. This system was developed with the cooperation and assistance of the British Columbia Ground water Association.

With this system, water well drillers will be able to organize and maintain their own water well data, print water well records for customers, and export data selected by the driller to the WELL database. Minimum system requirements are a personal computer capable of running the Windows 95/98/NT operating system.

Drinking Water Program (Ministry of Health Services)

Should I Get My Well Water Tested?
From the Ministry of Health Service's Health Files.

Download Adobe Acrobat's PDF Reader for free here.
This software will enable you to read and print reports that are in "portable document format" (PDF).

Our vision is a sustained and healthy ground water resource.

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It's true, the water we use today has been around for hundreds of millions of years, and the amount available probably hasn't changed very much. Water moves around the world, changes forms, is taken in by plants and animals, but never really disappears. It "travels" in a large, continuous cycle. We call this the Hydrologic Cycle (**"hydro"** means water).

ENTER

HOME

The Incredible Journey

(NOTE: In the printed version of the book, on page 161, this activity is found in a two color, three column format.

- **Grade Level:**
  Upper Elementary, Middle School
- **Subject Areas:**
  Earth Science
- **Duration:**
  Preparation time: 50 minutes
  Activity time: two 50-minute periods
- **Setting:**
  A large room or playing field
- **Skills:**
  Organizing (mapping); Analyzing (identifying components and relationships); Interpreting (describing)
- **Charting the Course:**
  Other water cycle activities include "Water Models" and "Imagine!" In-depth investigations of how water moves can supplement this activity: condensing and evaporating ("Water Models"), filtering through soil ("Get the Ground Water Picture"), traveling over Earth's surface ("Branching Out!"), and moving through the atmosphere ("Piece It Together").
- **Vocabulary:**
  condensation, evaporation, electromagnetic forces

Where will the water you drink this morning be tomorrow?

Summary
With a roll of the die, students simulate the movement of water within the water cycle.

Objectives
Students will:

- describe the movement of water within the water cycle.
- identify the states of water as it moves through the water cycle.

Materials

- *9 large pieces of paper*
- *Copies of* ***Water Cycle Table*** (optional)
- *Marking pens*

- *9 boxes, about 6 inches (15 cm) on a side* (Boxes are used to make dice for the game. Gift boxes used for coffee mugs are a good size or inquire at your local mailing outlet. There will be one die [or box] per station of the water cycle. [To increase the pace of the game, use more boxes at each station, especially at the clouds and ocean stations.] The labels for the sides of the die are located in the *Water Cycle Table* These labels represent the options for pathways that water can follow. Explanations for the labels are provided. For younger students, use pictures. Another option is to use a spinner. It is necessary to design a spinner for each station.)
- *A bell, whistle, buzzer, or some sound maker*

Making Connections
When children think of the water cycle, they often imagine a circle of water, flowing from a stream to an ocean, evaporating to the clouds, raining down on a mountaintop, and flowing back into a stream. Role-playing a water molecule helps students to conceptualize the water cycle as more than a predictable two-dimensional path.

Background
While water does circulate from one point of state to another in the water cycle, the paths it can take are variable.

Heat energy directly influences the rate of motion of water molecules (refer to the activity "Molecules in Motion"). When the motion of the molecule increases because of an increase in heat energy, water will change from solid to liquid to gas. With each change in state, physical movement from one location to another usually follows. Glaciers melt to pools which overflow to streams, where water may evaporate into the atmosphere.

Gravity further influences the ability of water to travel over, under, and above Earth's surface. Water as a solid, liquid, or gas has mass and is subject to gravitational force. Snow on mountaintops melts and descends through watersheds to the oceans of the world.

One of the most visible states in which water moves is the liquid form. Water is seen flowing in streams and rivers and tumbling in ocean waves. Water travels slowly underground, seeping and filtering through particles of soil and pores within rocks.

Although unseen, water's most dramatic movements take place during its gaseous phase. Water is constantly evaporating, changing from a liquid to a gas. As a vapor, it can travel through the atmosphere over Earth's surface. In fact, water vapor surrounds us all the time. Where it condenses and returns to Earth depends upon loss of heat energy, gravity, and the structure of Earth's surface.

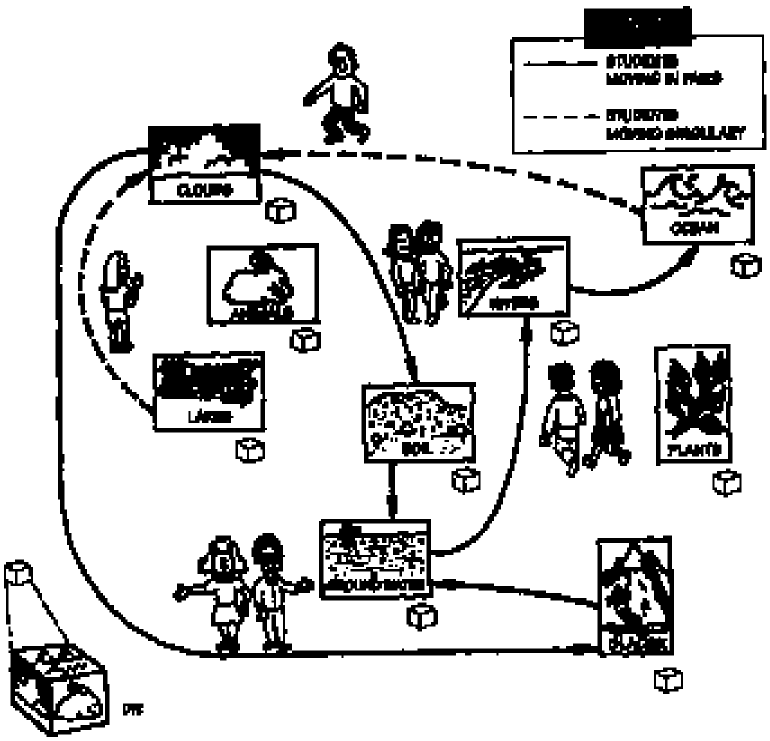
Water condensation can be seen as dew on plants or water droplets on the outside of a glass of cold water. In clouds, water molecules collect on tiny dust particles. Eventually, the water droplets become too heavy and gravity pulls the water to Earth.

Living organisms also help move water. Humans and other animals carry water within their bodies, transporting it from one location to another. Water is either directly consumed by animals or is removed from foods during digestion. Water is excreted as a liquid or leaves as a gas, usually through respiration. When water is present on the skin of an animal (for example, as perspiration), evaporation may occur.

The greatest movers of water among living organisms are plants. The roots of plants absorb water. Some of this water is used within the body of the plant, but most of it travels up through the plant to the leaf surface. When water reaches the leaves, it is exposed to the air and the sun's energy and is easily evaporated. This process is called transpiration.

All these processes work together to move water around, through and over Earth.

Using station illustrations, create a one page graphic on which students record their movements during the Incredible Journey



Procedure

Warm Up

Ask students to identify the different places water can go as it moves through and around Earth. Write their responses on the board.

The Activity

1. Tell students that they are going to become water molecules moving through the water cycle.

2. Categorize the places water can move through into nine stations: Clouds, Plants, Animals, Rivers, Oceans, lakes, Ground Water, Soil, and Glaciers. Write these names on large pieces of papers and put them in locations around the room or yard. (Students may illustrate station labels.)

3. Assign an even number of students to each station. (The cloud station can have an uneven number.) Have students identify the different places water can go from their station in the water cycle. Discuss the conditions that cause the water to move. Explain that water movement depends on energy from the sun, electromagnetic energy, and gravity. Sometimes water will not go anywhere. After students have come up with lists, have each group share their work. The die for each station can be handed to that group and they can check to se if they covered all the places water can go. The Water Cycle Table provides an explanation of water movements from each station.

4. Students should discuss the form in which water moves from one location to another. Most of the movement from one station to another will take place when water is in its liquid form. However, any time water moves to the clouds, it is in the form of water vapor, with molecules moving rapidly and apart from each other.

5. Tell students they will be demonstrating water's movement from one location to another. When they move as liquid water, they will move in pairs, representing many water molecules together in a water drop. When they move to the clouds (evaporate), they will separate from their partners and move alone as individual water molecules. When water rains from the

clouds (condenses), the students will grab a partner and move to the next location.

6. In this game, a roll of the die determines where water will go. Students line up behind the die at their station. (At the cloud station they will line up in single file; at the rest of the stations they should line up in pairs.) students roll the die and go to the location indicated by the label facing up. If they roll stay, they move to the back of the line.

When students arrive at the next station, they get in line. When they reach the front of the line, they roll the die and move to the next station (or proceed to the back of the line if they roll *stay*).

In the clouds, students roll the die individually, but if they leave the clouds they grab a partner (the person immediately behind them) and move to the next station; the partner does not roll the die.

7. Students should keep track of their movements. This can be done by having them keep a journal or notepad to record each move they make, including *stays*. Students may record their journeys by leaving behind personal stickers at each station. Another approach has half the class play the game while the other half watches. Onlookers can be assigned to track the movements of their classmates. In the next round the onlookers will play the game, and the other half of the class can record their movements.

8. Tell students the game will begin and end with the sound of a bell (or buzzer or whistle). Begin the game!

***Wrap Up and Action* Have students use their travel records to write stories about the places water has been. They should include a description of what conditions were necessary for water to move to each location and the state water was in as it moved. Discuss any *cycling* that took place (that is, if any students returned to the same station). Provide students with a location (e.g., parking lot, stream, glacier, or one from the human body-bladder) and have them identify ways water can move to and from that site. Have them identify the states of the water.**

Have older students teach "The Incredible Journey" to younger students.

Assessment
Have students:

- **role-play water as it moves through the water cycle (step 8).**
- **identify the states water is in while moving through the water cycle (step 4 and *Wrap Up*).**
- **write a story describing the movement of water (*Wrap Up*).**

Extensions
Have students compare the movement of water during different seasons and at different locations around the globe. They can adapt the game (change the faces of the die, add alternative stations, etc.) to represent these different conditions or locations.

Have students investigate how water becomes polluted and is cleaned as it moves through the water cycle. For instance, it might pick up contaminants as it travels through the soil, which

are then left behind as water evaporates at the surface. Challenge students to adapt "The Incredible Journey" to include these processes. For example, rolled-up pieces of masking tape can represent pollutants and be stuck to students as they travel to the soil station. Some materials will be filtered out as the water moves to the lake. Show this by having students rub their arms to slough off some tape. If they roll *clouds*, they remove all the tape; when water evaporates it leaves pollutants behind.

Resources

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- Lifewater International: Many water projects and resources!
- Lifewater Well Construction Manual (On-line Tutorial)

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Liquid Assets - Our Water Resources

Objectives

- To understand the relationships among water quality, water pollution, personal lifestyle, and the ecological health of the Lake Pontchartrain Basin.
- To develop an awareness of water resources and water quality.
- To understand the differences between point and non-point source pollution.

Multiple Intelligences Learning Activities

- *Verbal/Linguistic:* Write reflective journal entries on the impact of your personal lifestyles on the Lake Pontchartrain Basin or other nearby body of water. Write an essay or a poem about the water cycle.
- *Logical/Mathematical:* Calculate the amount of water used by your families per day and complete a chart on agricultural runoff.
- *Visual/Spatial:* Design posters of ways in which water is wasted and conserved. Construct signs for the "Water Cycle Walk".

- *Bodily/Kinesthetic & Musical/Rhythmic:* Step through the paces of the water cycle to musical accompaniment, stopping to explain the processes and products along the way. Make a "thunderstorm".

- *Interpersonal:* Brainstorm lists of ways in which water is wasted or conserved. Construct lists of things that affect water quality in the Lake Pontchartrain Basin.

- *Intrapersonal:* Write reflective journal entries on your personal impact on water quality in the Lake Pontchartrain Basin. Develop you own mini action plan.

Lessons

1. Water Cycle Lesson

2. Water Use

3. Measuring Water Quality

4. Water Pollution

Acknowledgement

This unit of lesson plans was adapted from the Lake Pontchartrain Basin Foundation's lesson plan source book for teachers of environmental education.

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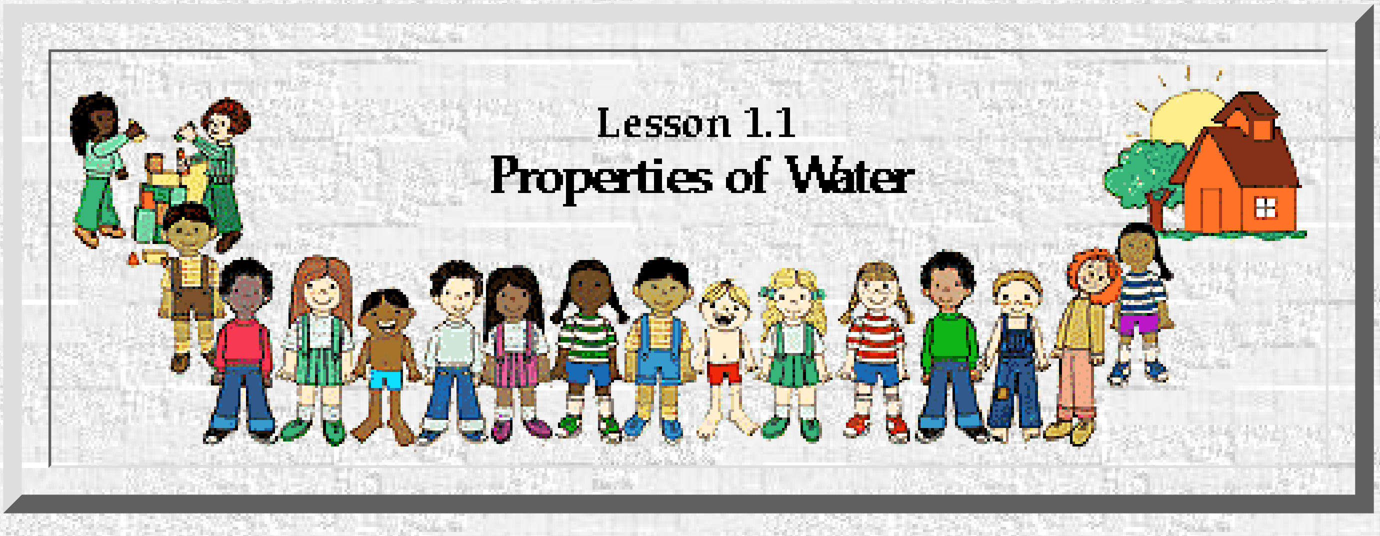

A. Biology Lesson

C. Knowledge Mapping Exercise

E. Alternative Ideas

F. Glossary

G. Lesson SemNet

H. Spanish/English SemNet

BioLinks

Audience & Background. These are NOT interactive, on-line lessons, but rather may be printed for use with **prospective and practicing K - 8 teachers**. (*NOTE: before printing these pages, go to the "Page Setup" option in Netscape and set the header to show page numbers. Also, we recommend setting Palatino as your proportional font in your General Preferences*). The underlying Instructional Philosophy is constructivist and should be reviewed before using these lessons. The lessons are designed to produce conceptual change and address some common alternative conceptions. Many of these lessons can be adapted for use in **elementary school classrooms**. Relevant Benchmarks from the American Association for the Advancement of Science (AAAS) are given at the end of the lesson. These national standards indicate the grade levels at which these ideas should be taught. Each lesson has six parts, including a biology lesson, knowledge mapping exercise, and glossary for students and for teachers, a teachers' guide for both the biology lesson and knowledge mapping exercise, and a table of persistent alternative ideas.

Authors and Acknowledgements

Correspondence

Water Related Lessons

Choose a lesson to view.

Title	Author(s)	Description	Implementation Hints
Elementary Level			
Rainforest Deforestation and the Water Cycle	ANGIE CARGILL, Shawna Steward	Students will use data and technology to develop an understanding of the relationship between deforestation of rain forests, the water cycle, and their daily lives.	No
Water Around Us	LORRAINE ETHERTON,	Students create a collage of human land use activities around an image of the Missouri River. Demonstration of Water Cycle and Properties of Water	No
Drip...Drop...Raindrops	SUSAN M FRACK, SCOTT PRICKETT	demonstrate the steps of evaporation, cloud formation, and precipitation within the water cycle. make and demonstrate how to use a hygrometer to record daily humidity. describe how rain, snow, and sleet form. show how to use a rain gauge to record daily precipitation.	No
Model of a Well	MARIANNE BONNEMIER,	Demonstrate the relationship of groundwater to wells.	No
Celebrate the Earth! - An Earth Week Unit	Michelle Garnett, Jessica Stoller	This unit was developed to help kindergarten students understand the concept of Earth Day using developmentally appropriate, hands-on activities, along with stories, songs and writing opportunities.	No
Middle Level			
History of Irrigation and Its Effects in Greeley County 1950-1999	POLLA HARTLEY, JOAN MCMANAMAN	This project will look at the affect that increased irrigation has had on a certain area, Greeley County, for the past 50 years. We will be looking over data for several different agricultural factors. These factors include number of irrigation wells registered in the county, number of irrigated acres, amount of corn production, price of corn, and cropland evaluation. We will also be looking	No

		at the climate data, temperature, precipitation and humidity, for the given period. Students will choose one of the above sets of data and prepare a report on their chosen topic, relating their topic to the increase of wells in the county.	
Dendritic River System	JOHN NIEMOTH,	This lab is an open ended lab with the ability to graph other drainage systems after making modifications to fit the desired drainage pattern.	No
Water Filtration	KIMBERLY FLESSNER,	Each group will design a water filtration system and present to the class, why they picked their design.	No
How Do Weather Conditions and Lunar Cycles Affect Fishing Success?	MARK SKILES,	Participating students will learn how to use weather measuring devices to record and study weather conditions at different locations, during different times. After much data collection, participating students will attempt to draw conclusions about the relationship between weather conditions, lunar cycle and fishing success.	No
Water Cycle	KIMBERLY FLESSNER,	To see how water is purified when it evaporates during the water cycle	No
Water Table	MARY LOU ALFIERI,	Become familiar with the term water table. Recognize the water table as one of the contributing factors in the existence of streams, swamps, and lakes in Nebraska.	No
Water Quality of Streams	MARK SKILES,	During this long-term research project, you will be studying and monitoring the water chemistry and quality of a local stream or river. Various tests will be done on a regular schedule to evaluate if water quality fluctuates throughout time or remains constant.	No
Water Flow Through Local Soils	LIZ SNYDER,	Determine the relationship between particle size and rate of water flow through soil. Suggest other variables that affect water flow through a soil.	No
Evidence for Trends in Climate Change	Danelle Schuh-Philippe, Suse Riddle	The purpose of this unit is to allow 8th grade Earth Science students to experience processes by which evidence is gathered about climate change over time. The students will be supported intheir science research and data collection by activities in their math class. With information gathered, students will then uses various techniques to assess trends in climate change.	No

Understanding Groundwater and the Effects of Pollution	Kerry Sievert, Valerie Lewis	Students evaluate population growth and increat pollution which results. The purpose and structure of landfills are studied. Groundwater is investigated. Students witness the effects of pollution on our water sup0ply through simulated activities and demonstrations	No
pHresh Air: Hits You in the Pocketbook	Lucinda Massey, Laura Krzysiak	pHresh Air: Hits You In The Pocketbook is an integrated unit of study focusing on the local effects of global air pollution. Students will study the causes and effects of acid rain, sources and locations of polluters in Wisconsin, and the effects of weather events on the movement of polluted emissions. Students will also study the Clean Air Act of 1994 and governmental programs to enforce and encourage compliance. Students will further study the proposed creation of the Chicago Energy Exchange as a vehicle for encouraging compliance.	No
Secondary Level			
Hard as a Rock	PAMELA GALUS, REBECCA L KADEL	A 2-week lab oriented activity that begins to show the relationship among human activities, rocks and soil formation.	Not Yet
Storage, Use, Pollution & Clean-Up	ROSEANNE WILLIBY,	An introduction to the storage, uses, pollution, and cleanup of water.	No
Recognizing Our Dynamic Wetlands	ROSEANNE WILLIBY,	Construct two wetlands: one with constant drainage and one that maintains a well-saturated soil. Maintain the wetlands for two weeks (minimum) and observe daily the soil, plant life, water level, and animal life if desired.	Yes
Flood Cycles 30/100 or Somewhere In-between	GREGORY PAUL PAVLIK,	Goal: To research flood history on a Nebraska river and to see if past precipitation records could be used for future predictions. Objective: Use current on-line references and Climprob to research a Nebraska river's flood history.	No
Permeabilty of Materials	Al MUSSEN,	Demonstrate the apparent difference of the permeability of various earth materials.	No
Flood Control	MARK SKILES,	This activity will help you understand (1) why dams have been built in Nebraska to create reservoirs, (2) what factors must be considered when building a dam and (3) how to design and build a dam yourself!	No

The Worm Wonderland: A Long Term Observational Science Project	Bob Feurer,	You have been working on observational techniques and the tools which help you make observations. This project is one which will give you reasons to use those skills already learned and will cause you to learn other new ones as well.	No
The Nebraska Brochure	Bob Feurer,	The primary goal of this activity is for students to discuss and decide what features of the state are and are not related to Nebraska earth science as they are doing their research and to then create a brochure which conveys their discoveries and decisions to the rest of the class.	No
Hydrology Investigation	Dana Krejcarek, Jessie Good	In this unit, students will be introduced to the GLOBE program and work specifcally with hydrology activities. GLOBE is an environmental program where students,teachers and scientist are able to share information. Students will gain an understanding of the importance owf water quality	No
Cross Level			
Water Cycle Mania	Lisa Overkamp, MARY LOU ALFIERI	Water Cycle and the effects of chemicals on the water system	Not Yet
What's up? Come On Down	James Servais, Sharon Rychter	Our unit is an interdisciplinary, cross-age study of weather involving first and ninth graders. Our goal is not only to teach and to actively engage our students in the subject content but to instill a love of learning and scientific inquiry through "hands-on/minds-on" experiences.	No

Nebraska Earth Science Education Network (NESEN)
Email: dgosselin2@unl.edu
113 Nebraska Hall
Univ. of Nebraska-Lincoln
Lincoln, NE 68588-0513

School of Natural Resources
University of Nebraska - Lincoln

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USGS
science for a changing world

Water Science for Schools

Welcome to the U.S. Geological Survey's (USGS) Water Science for Schools web site! We offer information on many aspects of water, along with pictures, data, maps, and an interactive center where you can give opinions and test your water knowledge. You can choose a topic from the menu below, get a description of our main water topics, or view our site map.

New! La Ciencia del Agua para Escuelas - Spanish version.

- Earth's water
- Water basics
- Water-use information
- Water Q&A
- Special topics
- Activity center
- Picture gallery
- NavGuide
- Help
- Search
- Glossary of water terms
- Certificate of completion
- Acknowledgements
- Links

Earth's water | Water basics | Water use | Water Q&A | Special topics | Activity center | Picture gallery

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USGS Learning Web ◆ USGS Water Resources home page

Comments? Contact hperlman@usgs.gov
The URL for this page is http://ga.water.usgs.gov /edu/index.html
Last Modified: Thursday, 26-Aug-2004 14:40:35 EDT
Water Science for Schools is USGS Water-Resources Investigations Report 98-4086

Water, Water Everywhere

Grade Level: Primary
Subject Area: Science
Essential Skills and Strategies:

Student creates and interprets graphs. Student shows appropriate connections within mathematics. Student communicates finds using appropriate mathematical terminology. Student observes and describes the physical properties of water. Student reads different materials for a variety of purposes. Student writes in a variety of forms for different audiences and purposes. Student understands and uses the steps of the writing process. Student selects and uses appropriate tools for measurement.

Materials: Needed: Computers with Internet access. Word processing program for report. Spreadsheet and graphing software. Scanner and printer to copy hydrological cycle picture.

Web sites used with the lesson:
1. National Oceanic and Atmospheric Administration: http://www.noaa.gov
2. Athena:
http://inspire.ospi.wednet.edu:8001/curric/weather/graphing/precip.html

Step One: Problem or Question
Students will compare the daily precipitation levels for two cities in the state of Washington (one on each side of the Cascade Mountains). Which city will receive the largest amount of precipitation? What geological features might impact which side of the state receives more precipitation? In addition, how does the hydrological cycle function and how is it impacted by geological features of the state?

Step Two: Getting Organized
With your teams get some background information about the hydrological cycle. Use of the following web site will assist you:
http://inspire.ospi.wednetedu:8001/curric/weather/graphing/precip.html.

Step Three: Gathering Information

Students will use links to get daily precipitation levels. Students will enter information on hand drawn spreadsheets for each of the two cities (your own and the city you are studying).

Step Four: Sorting and Analyzing Information
At the end of a one month period, students should ask and be able to answer the following question: Which of the two cities had the greatest amount of precipitation? Students will use the precipitation information off of their spreadsheet to create bar graphs for comparisons.

Step Five: Creating the Answer or Solving the Problem
Students will create by hand two separate spreadsheets (one for each city) and enter daily precipitation levels (Monday through Friday). Students will then create two separate spreadsheets on the computer and record daily precipitation levels for each city and save to a disk. At the end of the one month recording period, students will use the completed spreadsheet to create a bar graph of the precipitation levels by hand and then on the computer using their computer generated spreadsheets. Students will draw a picture of the hydrological cycle to be scanned, printed, and used as a report cover after students have inserted it into a document and titled it. Students will then report which city received the most rain and why. Students will explain the hydrological cycle and the Cascades impact on the amount of precipitation that falls on each side of the mountains.

Step Six: Evaluation
Evaluation of student work will be based on a class generated rubrics that will include some form of sharing, of the project, with the class.

This Research Lesson was created by Brian Ormsby
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Spokane, Washington

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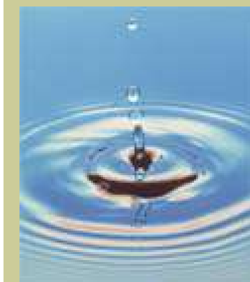
Related Article
Water: Pushing the Limits of an Irreplaceable Resource
By WILLIAM K. STEVENS



(Go to Article.)

Tuesday, December 8, 1998

Water, Water, Everywhere, Nor Any Drop to Drink

Water as a Limited Resource and the Technologies Created to Attempt to Best Use It

Author(s)
Alison Zimbalist, The New York Times Learning Network

Grades: 6-8, 9-12
Subjects: Geography, Science, Technology
Interdisciplinary Connections

Overview of Lesson Plan: In this lesson, students investigate the importance of water historically and in their daily lives and examine the nature of water as a limited resource. Students work in groups to research technological systems that have aimed to use water in the most productive ways, evaluate those systems, and create 'How It Works' posters of those systems that incorporate their research.
Review the Academic Content Standards related to this lesson.

Suggested Time Allowance: 45 minutes, plus homework

Objectives:
Students will:
1. List the various uses of water and discuss why water is a limited resource; review the water cycle and the environmental factors that determine which resources can be renewable.
2. Read and discuss "Water: Pushing the Limits of an Irreplaceable Resource."
3. Work in small groups to research dams, irrigation systems, aqueducts, pipelines, water purification systems, and sanitation systems.
4. Create a "How It Works" poster about their group's researched water system technology; present their work to the class.

Resources / Materials:
-paper
-pens/pencils
-classroom blackboard
-copies of "Water: Pushing the Limits of an Irreplaceable Resource" (one per student)
-science textbooks, encyclopedias, other print resources, and Internet access
-six large sheets of poster board
-markers

Activities / Procedures:
1. WARM-UP/ DO-NOW: In the first five minutes of class, each student lists all of the possible uses of water that come to his or her mind. Students then share their answers, and the teacher writes responses on the board. Then, discuss why water is a limited resource, reviewing the water cycle and the environmental factors that determine which resources can be renewable.

2. Read and discuss "Water: Pushing the Limits of an Irreplaceable Resource," focusing on the following questions:
a. According to the article, how were the earth and its geographic features formed?

b. As a class, create a graph illustrating the statistics discussed in paragraph 4. Why is the total amount of available, renewable freshwater difficult to measure?
c. How have technology and urbanization affected water usage? What different uses of water arise in an industrial area compared to an agricultural area?
d. What natural disasters are related to water, and how can these disasters affect humans?
e. How has human use of water biologically and geographically changed the earth?
f. Discuss the following quotation: "Because of the capacity for renewal, some experts believe there is probably enough water to meet burgeoning humanity's basic drinking, cooking, and sanitation needs for some time. That is the theory. In reality, more than a billion people do not have access to clean drinking water now."
g. Why would countries "run out of water in the future if they insist on producing their own food"? How does the presence of water relate to the wealth of a country?
h. What is irrigation, and why do some experts believe that "some dry areas will not be able to serve both the needs of farming and those of the ballooning cities" in the future?
i. How has water been a "source of conflict between regions, cultures, and countries," and why?
j. How is the use of water affected by growing population rates?
k. In what ways have developed countries begun using water more efficiently, and why were some of these changes made?
l. What is a dam, and why would environmentalists argue against them?
m. How is global warming expected to affect the earth's water?

3. Divide students into six groups. Assign each group one of the following technologies discussed in the article: dams, irrigation systems, aqueducts, pipelines, water purification systems, sanitation systems. Each group then researches their technology, using science textbooks, encyclopedias, other print resources, and the Internet to answer the following questions:
--When was this technology developed, and what problems was it designed to solve?
--How has this technology changed since its inception?
--How does this technology work? How does water travel through this system?
--How is the water in this system returned to be used again?
--How does this system contribute to environmental problems?
--What improvements could be made to this system?

4. WRAP-UP/ HOMEWORK: Groups conclude their research, if necessary. Each group then develops a "How It Works" poster about their technology. Posters should include:
--a detailed drawing of the technology system, accompanied by an explanation of how water travels through the system (a series of arrows can help with the visual aspect of this explanation)
--answers to the research questions, either in separate paragraphs or incorporated into the illustration of the system
In a future class, groups should present and explain their posters.

Further Questions for Discussion:
--Why should humans care about protecting the earth?
--What are ways in which humans pollute the land, sky, and water?
--Why do humans pollute the earth?
--What are ways in which humans can protect the environment?
--What role has technology played in both damaging and protecting our environment?
--How have technology and urbanization affected water usage?
--What different uses of water arise in an industrial area compared to an agricultural area?
--What natural disasters are related to water, and how can these disasters affect humans?
--How has human use of water biologically and geographically changed the earth?
--How does the presence of water relate to the wealth of a country?
--How is the use of water affected by growing population rates?
--In what ways have developed countries begun using water more efficiently, and

why were some of these changes made?

Evaluation / Assessment:
Students will be evaluated based on participation in class discussions, group research work, and group "How It Works" poster about their technology system.

Vocabulary:
ascendant, nascent, vaporized, aquifers, renewable, replenished, precipitation, finite, indispensable, elixir, accessible, diverted, appropriated, ecosystems, corseting, sluices, biosphere, sanitation, vagaries, siphoned, aqueduct, pipeline, runoff

Extension Activities:
1. Demonstrate the water cycle by creating a land mass and a water system in a margarine tub or similar container, covering it tightly with plastic wrap, and placing it under a heat lamp. Over the course of a few days, students will be able to note evaporation, condensation, and precipitation.

2. Study the impact of global warming on the earth's water supply.

3. Visit your town's local water works or treatment plant, or invite a guest speaker to visit your class. Students can create displays of how the plant works.

4. Learn about wetlands and the consequences of draining them. The National Audubon Society (http://www.audubon.org) is involved in preventing these efforts.

5. Research differences in life forms that live in saltwater and freshwater.

6. Develop strategies for conserving water in our daily lives.

7. Research pollutants and other environmental hazards that threaten the earth and its ecosystems (e.g., acid rain, deforestation, desertification, global warming, chloroflourocarbons, anoxia).

8. Learn about different views of how the earth and its features were formed, both scientific theories and mythological or religious ideas.

Interdisciplinary Connections:
American History- Learn about dam systems that are being removed to accommodate aquatic ecosystems across the United States.

Current Events- Locate news articles about or research recent floods, hurricanes, and tsunamis. Many Web sites contain photos, footage, data, and survivors' stories from these events.

Fine Arts- Locate songs that discuss pollution and the depletion of natural resources. Present the lyrics to the class. A good starting point is the Musicians United for Songs In the Classroom (M.U.S.I.C.) Web site, found at (http://www.wpe.com/~musici).

Global History
-Research "historic" uses of water (such as the 1938 destruction of dikes on the Yellow River to destroy part of a Japanese army invading China).
-Learn about water systems in developing countries and the special health and environmental issues raised there.
-Research some of the conflicts mentioned in the article that were caused by water resources.

Health
-Research pollutants found in water and how they can affect public health.
-Learn about water's role in sustaining human life, from individual cells to whole systems of the human body.

Language Arts- Read and analyze flood myths from a wide variety of ancient cultures.

Mathematics- Keep track of your city's daily precipitation (usually available in the local newspaper or on the local news) and illustrate it graphically.

Other Information on the Web

The International Water Management Institute's World Water and Climate Atlas (http://www.iwmi.org) is a growing collection of data products and analytical tools focused on climate and water resources. Examples of what can be done with the Atlas include: identify areas suitable for rainfed agriculture, provide inputs for hydrologic modeling of river basins, extract climate inputs for crop modeling, and help project water supply and demand globally, nationally, and by river basins.

3-D Atlas (http://www.3datlas.com) offers research information on maps, culture, the natural world, climate, and human impact (as well as other categories), and allows you to search for information on specific countries.

Web sites dedicated to saving the environment:
--Environmental Defense Fund: (http://www.edf.org)
--National Audubon Society: (http://www.audubon.org)
--World Wildlife Fund: (http://www.worldwildlife.org)
--The Nature Conservancy: (http://www.tnc.org)
--Sierra Club: (http://www.sierraclub.org)
--Students Environment Action Coalition: (http://www.seac.org)
--Defenders of Wildlife: (http://www.defenders.org)
--Cousteau Society: (http://www.cousteau.org/AN/welcomeh.html)
--Environmental Protection Agency: (http://www.epa.gov)

Academic Content Standards:

McREL This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8
Science Standard 1- Understands basic features of the Earth. Benchmarks: Knows the processes involved in the water cycle and their effects on climatic patterns; Knows the properties that make water an essential component of the Earth system
Geography Standard 14- Understands how human actions modify the physical environment. Benchmarks: Understands the environmental consequences of people changing the physical environment; Understands the ways in which human-induced changes in the physical environment in one place can cause changes in other places; Understands the ways in which technology influences the human capacity to modify the physical environment; Understands the environmental consequences of both the unintended and intended outcomes of major technological changes in human history
Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Knows the ways in which human systems develop in response to conditions in the physical environment; Knows how the physical environment affects life in different regions; Knows the ways people take aspects of the environment into account when deciding on locations for human activities; Understands relationships between population density and environmental quality
Geography Standard 16- Understands the changes that occur in the meaning, use, distribution and importance of resources. Benchmarks: Understands the reasons for conflicting viewpoints regarding how resources should be used; Knows strategies for wise management and use of renewable, flow, and nonrenewable resources; Knows world patterns of resource distribution and utilization; Understands the consequences of the use of resources in the contemporary world; Understands the role of technology in resource acquisition and use, and its impact on the environment; Understands how energy resources contribute to the development and functioning of human societies; Understands how the development and widespread use of alternative energy sources (e.g., solar, wind, thermal) might have an impact on societies (in terms of, e.g., air and water quality, existing energy

industries, and current manufacturing practices)
Geography Standard 18- Understands global development and environmental issues. Benchmarks: Understands how the interaction between physical and human systems affects current conditions on Earth; Understands the possible impact that present conditions and patterns of consumption, production and population growth might have on the future spatial organization of Earth
Technology Standard 3- Understands the relationships among science, technology, society, and the individual. Benchmarks: Knows that science cannot answer all questions and technology cannot solve all human problems or meet all human needs; Knows ways in which technology has influenced the course of history; Knows that technology and science are reciprocal; Knows ways in which technology and society influence one another

Grades 9-12
Science Standard 1- Understands basic features of the Earth. Benchmark: Knows how life is adapted to conditions on the Earth
Geography Standard 14- Understands how human actions modify the physical environment. Benchmarks: Understands the global impacts of human changes in the physical environment; Knows how people's changing attitudes toward the environment have led to landscape changes
Geography Standard 15- Understands how physical systems affect human systems. Benchmark: Knows changes in the physical environment that have reduced the capacity of the environment to support human activity
Geography Standard 16- Understands the changes that occur in the meaning, use, distribution and importance of resources. Benchmarks: Understands programs and positions related to the use of resources on a local to global scale; Understands the impact of policy decisions regarding the use of resources in different regions of the world; Knows isues related to the reuse and recycling of resources
Geography Standard 18- Understands global development and environmental issues. Benchmarks: Understands why policies should be designed to guide the use and management of Earth's resources and to reflect multiple points of view; Understands contemporary issues in terms of Earth's physical and human
Technology Standard 3- Understands the relationships among science, technology, society, and the individual. Benchmarks: Knows that science and technology are pursued for different purposes; Knows examples of advanced and emerging technologies

Send feedback on this lesson.

Browse or search the lesson plan archive.

SCIENCE Junction

Tutorial for Teachers

- Register for Water What-ifs Program
- Teacher Tutorial password needed

Feedback

- Web Site Usability Survey

Reference Desk

- LaMotte Homepage
- Texas Instruments Homepage
- Water Related Websites
- Just for Kids
- Macroinvertebrates
- Warning Signs of Pollution
- Water What-ifs References

User Guides

- Using LaMotte Water Quality Test Kits
- Using Calculator-based Laboratory(CBL) Equipment

Web Links for Teachers

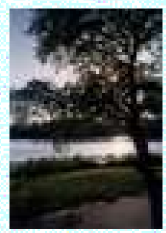
- Examples of Acceptable Use Policies
- Collaborative Projects and Data Sets

Water What-ifs

Introduction to Water What-ifs

Water What-ifs is a web site for encouraging inquiry investigations of water quality in North Carolina and Delaware. It is dedicated to the students of these two fine states. The following links will introduce you to the watersheds of your state!

- Surf your watershed in Delaware!
- Surf your watershed in North Carolina!
- Find the latitude and longitude of your location!



The following water quality parameters will be addressed at this site. Three lessons are provided for each parameter to help teachers create a water quality unit to be used in conjunction with the water quality testing program.

pH

temperature

dissolved oxygen

nitrates/phosphates

macroinvertebrate surveys

The purpose of water quality testing is to monitor specific parameters in bodies of water on the earth. Changes in these parameters may be detrimental to the organisms in and around the water source. Many factors

- [Info on Available Grants]
- [National Science Standards]
- [North Carolina Science Curriculum]
- [Delaware Science Standards]
- [Water What-ifs Workshop Photos]

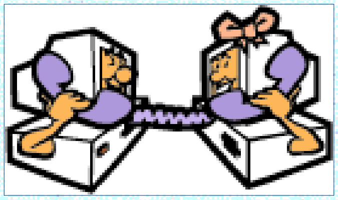
Water Quality Data

- Submit water quality data (password needed)
- Look at NC Data
- Look at Delaware Data
- Using Collected Data for Inquiry Lessons

can affect the quality of the water in a ecosystem including discharges of industrial or agricultural wastes.

Field observations and measurements allow us to look for links between land use and its effects on water quality. By collecting and analyzing data from a local source we can approach a community situation in a way very similar to the approach used by practicing scientists.

Water Quality Forum (password needed)



The Water Quality forum allows interaction and discussions on investigations of water quality. Please try to post to the forum once each week to help form an on-going dialogue.

Please note! The use of this site is being monitored for educational research purposes. Data collected from the use of this site may be included in published research. We encourage teachers to participate by visiting the Teacher Tutorial.

Back to the top

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e-mail the author

page design by Lisa Leonor Grable and April J. Cleveland
URL: http://www.ncsu.edu/sciencejunction/depot/experiments/water/index.html
Last Modified: 8/11/01

| Data Depot | Science Junction | NC State University |

Educational Resources in Aboriginal Studies

Curricular Resources **(Information/explanations for students and teachers wishing to learn more about Aboriginal Studies)**
Aboriginal Studies (CR)
Instructional Materials **(Lesson plans and teaching tips/ideas for Aboriginal Studies teachers)**
Aboriginal Studies (IM)
Theme Pages **(Curricular resources as well as Instructional Materials on specific Aboriginal Studies topics)**
Explorers
First Nations History
First Nations Treaties, Law, and Land Claims
Masks

Previous Screen

Asteroids, Comets, and Meteors Theme Page

This "Theme Page" has links to two types of resources related to the study of asteroids, comets and meteors. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. Please read our disclaimer.

- ## Asteroid and Comet Impact Hazards

  "Although the annual probability of the Earth being struck by a large asteroid or comet is extremely small, the consequences of such a collision are so catastrophic that it is prudent to assess the nature of the threat and prepare to deal with it." This NASA site provides basic information about such possibilities including government reports and FAQs about impacts, asteroids and comets.

- ## Build Your Own Comet

  Advice and a recipe for building a six inch comet. The site also provides basic information about comets.

- ## Constellation Prizes

  In this lesson plan, grade 6-12 students "learn about meteors, meteorites, and comets by reading and discussing a related New York Times article about the Leonid meteor showers and the methods that scientists are using to learn from these meteors. Students then create and observe a comet in their classroom."

- ## Database of Terrestrial Impact Structures

  Natural Resources Canada provides world maps identifying crater locations. Regional maps also offer links additional information about the craters. Be sure to look at the paper "Impact Cratering on Earth" for crater information, morphology, identification and hazards although the writing is at somewhat of an advanced level.

- ## Explore Zone

  EZ provides general information followed by a page with collections of news stories about the latest innovations, coolest discoveries and hottest events in world of science. Although not written specifically for kids, the articles provide information written appropriately for them

  - Asteroid Science
  - Comet Science
  - Meteor Science

- ## Impact Craters

A lesson for junior high students from NASA on impact craters. Topics include an explanation of impact craters, pseudocrates, and impact craters in other parts of the solar systems. The question of whether or not we are in danger is also addressed. A teacher's guide is available but doesn't appear to be linked from the student lesson site.

- ## Meteorite and Impacts Advisory Committee (MIAC)

Three topics are discussed in this Canadian Space Agency site: meteorites, fireballs, and impact structures. General information about each is provided and there are some specific Canadian references as well.

- ## Meteors

This lesson from Newton's Apple introduces meteors and provides an activity where students can learn more about craters and what made them.

- ## Sky and Telescope

The online version of the 58 year old magazine.

  - Asteroids Brief, general information about asteroids combined with related articles on hunting asteroids and seeing asteroids.
  - Comets General information about comets plus related articles on comet observing as well as specific comets.
  - Meteor Page General information about meteors as well as links to related articles on planning a meteor watch, observing meteors, meteors that changed the world, and information about specific meteor showers.

- ## Small Comets

Learn more about the theory that millions of small comets strike the earth yearly and break up into water vapour. Some scientists believe that they are the source of water in Earth's oceans and atmosphere. Be sure to read the sections "The Original Discovery","Your Questions Answered", and "Latest News".

- ## Solar System Collisions

Students are able to manipulate four variables (target, projectile composition, projectile diameter, and projectile velocity) to determine how they affect the impact of a collision of an asteroid or a comet on a solar body.

- ## StarChild: The Solar System

StarChild is a comprehensive NASA site developed for elementary students. The above link is to their "Level 1" menu page on the solar system where you will find links to their sections on The Asteroid Belt, Comets, and Meteoroids. Each of these sections provides a brief introduction with all terms defined in a gloasary, a comprehension question, and a probing question. All pages come in two reading levels and can be printed.

- ## StarDust

Launched in February 99, StarDust is a NASA mission that will fly close to a comet and bring cometary material back to Earth. Their web site has: mission description, status reports, and details (e.g., scientific objectives, flight plans); explanations about comets; comet history; description of the spacecraft; overview and discussion of the scientific concepts involved in the mission; photos and images; and an education page with activities and a teacher guide.

TrackStar

TrackStar is an online interface which allows instructors to create lessons for students by sequencing existing instructional content in various web sites within a lesson. Students explore one topic at a particular location within one web site then move on to the next topic at another web site. The list of topics remains visible throughout the lesson so that students can remain on track. Explorations of the web sites beyond the designated instructional content are also possible.

This link is to their search page from where a keyword search on "asteroids or comets or meteors" will produce over a dozen hits. Note however that many of these hits will have the study of asteroids etc. as only a part of their overall lesson. Caution #1: Many of the web sites that these lessons access may already be on this CLN page - it's the creation of lesson objectives and the sequencing of the tours through the sites that make the lesson potentially useful to your students. Caution #2: The quality of the lessons (e.g., definining objectives, finding web sites, sequencing the tours) will vary widely within the TrackStar collection.

Views of the Solar System: Table of Contents

This site has sections covering a wide range of solar system topics. It can be difficult to find all of the good resources on the site since they do not appear to be all interlinked. Your best bet is to use this table of contents to browse through the asteroid, comet and meteor sections. You'll find introductions about each type of body, information about specific examples, images, explanations of various scientific phenomena, and a number of classroom activities.

[The] Why Files

- Asteroids Answers to the following questions: What can they do? Will they obliterate Earth? How are asteroids found? Did asteroids deliver life? What are they made of?
- Comets Information is organized under the following headings: Comet fiction; Comet facts; Do-it-yourself comet; Extrasolar what? Where do they come from? Could a comet crash into the Earth? Are they trying to tell us something? Are we listening?

Top of Page

Note: The sites listed above will serve as a source of curricular content in Asteroids, Comets and Meteors. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Curricular Resources in Astronomy

Here are a number of links to Internet sites which contain information and/or other links related to Astronomy. Please read our disclaimer.

- ## Amazing Space

  The Space Telescope Science Institute - the organization responsible for the scientific operation of the Hubble Space Telescope - hired teachers to develop a collection of K-12 web-based interactive astronomy lessons complete with student activities and teacher guides. There are several different units with topics on: Black Holes, Galaxies, Stars, the Solar System, Telescopes, Hubble Space Telescope.

- ## Ask an Expert: Astronomy

  CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on Astronomy may be found in our "All Subjects" section at the top of the page, the "Science" section, as well as the general "Reference" section.

- ## [An] Astronomy Course for Students Using the Internet

  An Internet-based course on astronomy that should be adaptable to most age and interest levels.

- ## Astronomy Education Resources

  Here's a meta-list of links to educational astronomy sites with descriptions.

- ## Astronomy WWW Resources

  This meta-list has categories of astronomical services, like general collections, e-zines, specialized areas, and servers around the world.

- ## Athena Curriculum: Space and Astronomy

  Athena has used geophysical and other data sets acquired via the Internet to prepare curricular units on space and astronomy.

- ## BC's Pacific Space Centre

  The on-line location of BC's H.R. Macmillan Planetarium and Gordon Macmillan Southam Observatory. Increase your awareness about the space center's different program offerings, and find out about the forecast for the night skies for the upcoming month.

- ## Bradford Robotic Telescope

  At this site you can control a remote and fully automated 46 cm telescope connected to the Web. Just register (it's free) with this telescope, located high on the moors in West Yorkshire, England and ask it to look at absolutely anything in the Northern night sky. It decides when the conditions are good enough to make observations, then posts the documentation, results, and photo of your job.

- ## Comets and Meteor Showers

The "Comet" segment of this site contains accurate positions of each currently visible comet, on-line star charts, photographs and information on interesting historical comets. In the "Meteor" segment, information on meteor showers is divided by month with information provided on each shower.

- Eric's Treasure Troves of Science

Extensive on-line encyclopedias of math and science. Included are encyclopedias on Astronomy, Scientific Biography, Scientific Books, and Rocketry. Each section is browsable alphabetically or searchable by keyword. Entries have a concise explanation as well as cross links which can be quite extensive.

- Expanding Universe: A Classified Search Tool for Amateur Astronomy

Here's a meta-list of links to astronomy www sites, but with a difference. It uses a modified Dewey Decimal System to organize the links.

- Mission to Mars

The content of this ThinkQuest 1997 award winning site covers the history of Mars, man's fascination with it, and our exploratory missions. There's lots of information in the pages in the 'Mars Academy' or students can learn about the planet through an interactive mission simulation in which they design and execute a mission probe.

- NASA Education Internet Links

Links to the multitude of NASA educational resources.

- National Air and Space Museum (Smithsonian Institution)

Take a 'Virtual Tour' of this museum.

- Outer Orbit

This site has a number of curricular resources for students and teachers, including: Space Chat (talk with professionals); Ask an Astronomer (question and answer service); Today in Space (look through a telescope or link to an online magazine/newspaper); Mission Mars (information about this project); International Space Station (keep up to date with what's happening); and links to other space related sites.

- Rader's Interactive Space Exploration Center

Instructional units on a range of topics within five major astronomical sections: Universe, Galaxies, Stars, Solar System, and Explore. Generally, each topic is presented within one or two screen pages.

- Science for the Millenium

This virtual exposition from the National Center for Supercomputing Applications (NCSA) has a number of very extensive exhibits for astronomy students and teachers. Movies and sound enhance the site but are not absolutely necessary.

  - Cosmos in a Computer Learn more about cosmology - the study of the universe as a whole. Topics include: How did the universe begin? How did it come to be in its present state? What can the universe's present structure tell us about its evolution and ultimate fate? Why are computers essential to understanding the universe? What does it take to compute the cosmos? There are also lots of scientific animations.

- Spacetime Wrinkles Questions addressed in this exhibit are: Who was Einstein? What is gravity? What are black holes and gravitational waves? Where might black holes lurk? How can we "see" them? What does it take to study black holes? What happens if you disturb a black hole? What happens when two black holes collide? Will Einstein's theory of gravitation continue to prevail in decades to come?
- Whispers for the Cosmos Learn more about how radio astronomers use computers to analyze huge amounts of data in an attempt to answer questions such as: Is space really empty? What lies between the stars? Can molecules, including those we're made out of, form in space? How are stars born? What determines the shapes of galaxies?

SEGway

The Science Education Gateway provides Earth and Space Science curricula produced by teachers in collaboration with SEGway partners (e.g., NASA, Science Museums). Lessons, activities and self-guided tutorials are categorized under "Space Science", "Sun/Earth", and "Solar System." (Note: you may find some of the same lessons in the web sites of its partners.)

StarChild

Designed for children, this site has two difficulty levels of content on the Solar System, the Universe, and Space Stuff. Within each area, there is a set of student activities that children can perform online.

Students for the Exploration and Development of Space (SEDS)

This site contains information about SEDS and about space science in general for students at the high school or university level interested in forwarding the cause of space exploration and development.

Views of the Solar System

Views of the Solar System contains images and information about the Sun, planets, moons, comets, asteroids, and meteoroids. There are over 220 pages of information and 950 images.

[The] Whole Mars Catalog

Information about Mars as well as Mars Missions.

Windows to the Universe

Funded by NASA, this site contains Earth and Space Science documents, including images, movies, animations, and data sets, targeted for elementary, middle school and high school students. Documents provide not only scientific content, but also information about the artistic, historical, and cultural connections between science and our lives. Teacher resources include classroom activities and educational links.

Note: The sites listed above will serve as a source of curricular content in Astronomy. For other resources in this subject area (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Curricular Resources in Geology

Below are the CLN "Theme Pages" which focus on specific topics within Geology. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality Theme Page
- Avalanches Theme Page
- **Biomes Theme Pages**
  - Antarctic Theme Page
  - Arctic Theme Page
  - Drylands/Deserts Theme Page
  - Temperate Forests Theme Page
  - Tropical Rainforests Theme Page
  - Wetlands Theme Page
- Earthquakes Theme Page
- Floods Theme Page
- Glaciers Theme Page
- Oceanography Theme Page
- Rocks, Minerals, and Mining Theme Page
- Tsunamis Theme Page
- Volcanoes Theme Page
- Water Quality Theme Page

General Geology Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Geology. Please read our disclaimer.

- Ask an Expert: Geology

  CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on Geology may be found in our "All Subjects" section at the top of the page, the "Science" section, as well as the general "Reference" section.

- ## Athena Curriculum

  Athena has used geophysical and other data sets acquired via the Internet to prepare curricular units on oceans and earth resources.

- ## Earth and Sky

  Earth and Sky" is a radio program where popular science topics are discussed at a level that's appropriate for non-scientists. The transcripts for each current week are available online (formerly via gopher and now on the World Wide Web). As part of the service, you can submit your own questions and you can browse the scripts from previous shows.

- ## Fundamentals of Physical Geography

  Although this online textbook from Michael Pidwirny, Okanagan University College, is intended for postsecondary students studying introductory physical geography, much of it may be applicable for high school students as well. Contents include over two hundred pages of information, more than three hundred 2-D and animated graphics, an interactive glossary of terms, a study guide, links to other Internet resources, and a search engine. See the Table of Contents to directly access such sections as Meteorology and Climatology, Hydrology, Biogeography and Ecology, Geology, and Geomorphology.

- ## **New York State Regents Examinations**

  The N.Y. State Regents Examinations are a set of subject-based standardized tests for N.Y. high school students. Here are two resources, from different organizations, that can help teachers and students prepare for these or other similar standardized exams.

  - New York State Education Department Download PDF formatted copies of recent Regents Examinations and answer keys from this page.
  - Regents Exams Prep Centre: Earth Science The Prep Centre, developed by Oswego County high school teachers, is intended to help Grade 12 teachers and students prepare for the N.Y. Regents Exams. Teachers can access sets of sample questions that are organized by subject and then by topic. Alternatively, students can attempt the questions, view the correct answer, or follow a link to a tutorial on the curricular content in the question if they need assistance.

- ## Pointers to Earth System Science Educational Resources

  Pennylvania State University provides a meta-list of links to on-line Earth System Science Education resources, categorized under headings such as "Earth Science", "Environment", "Weather", "Geography", "Teacher Resources" and "Kids (K-12)."

- ## RiverResource

  Students will be able to find resources on rivers in general as well as some specific rivers. Although that section of the site is predominantly American, some Canadian rivers are included.

- ## Schlumberger: Science Watch

Learn more about the oil industry with these articles provided by Schlumberger: 1) Nuclear Magnetic Resonance Six Miles Deep: 2) Physics in the Oil Industry; 3) Drilling Fluid: Lifeblood of the Well; 4) CyberGeologist; 5) The JOIDES Resolution; and 6)The Making of Oil Plankton to Production.

- ## SEGway

  The Science Education Gateway provides Earth and Space Science curricula produced by teachers in collaboration with SEGway partners (e.g., NASA, Science Museums). Lessons, activities and self-guided tutorials are categorized under "Space Science", "Sun/Earth", and "Solar System." (Note: you may find some of the same lessons in the web sites of its partners.)

- ## United States Geological Survey

  The USGS provides a variety of resources for earth science students and teachers.

  - Earth and Environmental Science A meta-list of Earth and Environmental Science Internet resources categorized under such topics as "Earth Science", "Earthquake", "Environment", "Hydrology", "Oceanography" and "Volcanology."
  - Teaching in the Learning Web Lessons and activities in two earth science categories: Changing World and Earth Hazards. There is also a unit on maps.
  - Water Science for Schools High school and middle school students can learn about the basics of water, Earth's water, special topics (e.g., acid rain, water quality issues), and US water use. There also are some interactive sections, FAQs, and links to other sites.

Top of Page

Note: The sites listed above will serve as a source of curricular content in Geology. For other resources in this subject area (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Curricular Resources in Paleontology

Here are a number of links to Internet sites which contain information and/or other links related to paleontology. Please read our disclaimer

- Ask an Expert: Paleontology

  CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on Paleontology may be found in our "All Subjects" section at the top of the page, the "Science" section (see General Science), as well as the general "Reference" section.

- Dinosaur Theme Page

  This CLN "Theme Page" has links to two types of resources related to the study of dinosaurs. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- [The] Field Museum: Online Exhibits

  The Field Museum of Natural History (Chicago) has a number of online exhibits that will be of interest to paleontology students. Check out "Sue on the Web" for a T.Rex exhibit and "Life Over Time" for information about dinosaurs in general.

- Paleontology without Walls

  Take a 'Virtual Tour' of this University of California museum. Their "On-line Exhibits" contain large amounts of information on paleontology, searchable by phylogeny, geology or evolutionary theory as your paradigm.

- PaleoWorld

  The goal of the developers of this site is to further the interest and understanding of the flora and fauna that have existed over the past 650 million years. Information is organized by geological period (the site is still under development). Students will be able to learn about any existing animals and plants, get a reconstruction of the paleogeography of the continents, and read a description of what the Earth was like at the time.

- Set in Stone

  This paleontology site has background information about paleontology in general as well as fossils and dinosaurs in specific. There is also a series of classroom activities for students.

- Strange Science: The Rocky Road to Modern Paleontology and Biology

  Today's knowledge about biology and paleontology is often taken for granted. This web site uses historical paintings and images to demonstrate some of the weird ideas that scientists and scholars in these subjects previously held.

Top of Page

Note: The sites listed above will serve as a source of curricular content in Paleontology. For other resources in this subject area (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Curricular Resources in General Science

Below are the CLN "Theme Pages" which focus on specific topics within General Science. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme. We have many other, more specific, Theme Pages. You'll find a list at our Science Menu Page

- Inventors and Inventions Theme Page
- Science Fair Theme Page

General Science Resource

Here are a number of links to other Internet resources which contain information and/or other links related to General Science. Please read our disclaimer.

- Ask an Expert: General Science

  CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on General Science may be found in our "All Subjects" section at the top of the page, the "Science" section, as well as the general "Reference" section.

- AskERIC

  "ERIC" stands for the "Educational Resources Information Center" - a U.S. federally funded national information system that provides a variety of services and products. "AskERIC", the Internet-based equivalent, contains two major components which may be of interest to Science teachers: (1) the AskERIC Q&A service enables teachers to send a message requesting educational information. The Center staff will search the ERIC databases and respond within 48 hours. (2) The AskERIC Virtual Library contains hundreds of lesson plans, access to the ERIC database and ERIC Digests, topical guides to Internet Resources, and archives of education-related listservs.

- Athena Curriculum

  This web site provides curricular and resource material using geophysical and other data sets acquired via Internet. At the time of viewing, they had four folders of resources: Oceans, Weather and Atmosphere, Earth Resources, and Space & Astronomy. A folder might have links to curricular resource materials (e.g., data, other WWW sites) as well as instructional materials for the teacher and/or student.

- BC's Science World

  Access information about BC's Science World programs and events, membership, history, and helpful hints to plan your school trip.

- Brainium

Here's a made-in-BC multimedia educational resource that combines electronic games with other interactive resources such as an online science magazine, conferencing, virtual chat sessions, web site and software reviews, and an on-line, animated episodic show called BugZone. A teacher resource area will assist teachers in integrating Branium resources in the grade 4-8 science curriculum. Note: BC teachers and students can access Branium through a province wide license, but they must first go through a registration process. Note also that the technology in this site will require use of an advanced browser.

- Celebrating Science and Technology Week

This page was developed by Mike Silverton of Nanaimo School District for the 1996 Science and Technology Week. The resources available from this site should be useful to BC students and teachers at any time.

- Cornell Theory Center Math and Science Gateway

This Gateway provides a meta-list of links to resources in mathematics and science for educators and students in grades 9-12.

- Eisenhower National Clearinghouse for Mathematics and Science Education

The Eisenhower National Clearinghouse for Mathematics and Science Education (ENC) provides information about all types of instructional resources including books, videos, software, CD-ROMs, kits, and online resources. The Digital Curriculum Laboratory (DCL), ENC's online component, is a comprehensive Internet site for math and science education. It is designed to assist teachers in locating instructional and other educational resources. The DCL includes links to Internet resources for science and math teaching as well as the ENC Catalog of Curriculum Resources.

- ERIC Clearinghouse for Science, Mathematics, and Environmental Education

This ERIC Clearinghouse provides educational materials, services and coursework to parents, educators, students and others interested in Science. Specific resources include lesson plans, research summaries (Digests), electronic publications, indexed journals and information about scientific organizations.

- Evidence: The True Witness

Explore the field of forensic science in this ThinkQuest 98 entry. Learn about the fundamentals of the science in the reference section, test your knowledge of the science by collecting evidence and trying to solve a simulated crime, or learn about potential careers in this field. Note that advanced technology is needed to access sections of the site.

- Explorer Data Base

The explorer is an on-line database by which educational resources in mathematics and science (instructional software, lab activities, lesson plans) can be contributed, organized, or delivered.

- [Great Canadian Scientists Online]

  This site contains the short biographies of about 20 famous Canadian scientists. There are about 100 other Canadian scientists which are profiled briefly. In addition, students can email science questions directly to Canadian Scientists.

- [Jason Project]

  This site provides a link to the current Jason Project hosted by the Jason Foundation for Education. "Jason Projects" enable teachers and students to participate in an electronic field trip hosted by scientists engaged in global explorations.

- [[The] Mad Scientist Network]

  Here's a Web-based "Ask a Scientist" forum for teachers and students. Questions can be posted in any one of 24 science areas and a scientist will answer them. There's also a browsable and searchable question/answer archive.

- [Measure 4 Measure]

  This is a meta-list of about 100 links to site which will perform calculations/estimates for you. Categories include: Science/Math (e.g., measurement conversions); Health (e.g., calorie counter); Finance (e.g., compound interest); and Miscellaneous.

- [Minnetonka Elementary Science Center]

  The Science Center is a warehouse-type resource centre for Minnetonka School District teachers. Some of the information on this web site pertain only to the operations of that center. However, there are other electronic resources which will be useful to any elementary science teacher, including lesson plans (organized by grade levels) and teacher tools (e.g., practical suggestions on science fairs).

- [Recurring Science Misconceptions in K-6 Textbooks]

  Explanations of over 25 commonly believed misconceptions about scientific principles.

- [SciEd: Science and Mathematics Education Resources]

  This site is a meta-list of links to educational science resources, organized by subject. It also includes documents such as "History of Science", "Ethics in Science", and "Skepticism and Pseudoscience".

- [ScienceDaily]

  The site developers describe their site as follows: "Each day, ScienceDaily will bring you breaking news about the latest discoveries and research projects in everything from astrophysics to zoology.... ScienceDaily also offers the best collection of hotlinks to the coolest science sites on the World Wide Web, as well as weekly updates e-mailed directly to you."

- [Science Hobbyist]

  Here's a site aimed at the amateur scientist. This page includes links to scientific newsgroups, sites, and useful scientific information. It also specializes in linking to science demos, 'wierd science' sites, science museums and home schooling information.

- [Science Links]

  This SchoolNet page contains links to: "Images of Canada" (learn about satellite imagery); "National Pollutant Release Inventory (a database on major sources of environment pollutants); and "Canadian National Earthquake Hazards Program" (earthquake records).

- [ScienceWeb]

  ScienceWeb is a science and technology information service that focuses on Canadian activities. Included within the site are: a resource guide to Canadian post secondary institutions; information on science internet projects that K-12 kids can get involved with; a teachers helping teachers corner; and, links to scientific institutions, clubs and non-profit societies.

- [The] Why Files

  "The Why Files, a project of the National Institute for Science Education, is an electronic exploration of the science behind the news. Twice a month, we'll bring you a new feature on the science (and math, engineering, and technology) of everyday life. Our boundaries are broad -- from outer space to cellular biology, from dinosaurs and dragon lizards to the statistics of political polling."

- Yahoo's Catalog for Science

  A very large list of science links, organized by subject area.

- You Can

  Beakman and Jax provide lots of science-related information, pictures, interactive demos, and experiments/activities for kids.

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Note: The sites listed above will serve as a source of curricular content in General Science. For other resources in this subject area (e.g., curricular content in Earth Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Curricular Resources in Life Science

Below are the CLN "Theme Pages" which focus on specific topics within Life Science. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Biomes Theme Pages**
  - Arctic/Antarctic Theme Page
  - Drylands/Deserts Theme Page
  - Temperate Forests Theme Page
  - Tropical Rainforests Theme Page
  - Wetlands Theme Page
- Endangered Species Theme Page
- Gardening for Kids Theme Page
- Genetics/Biotechnology Theme Page
- Gerbils-Hamster Theme Page
- **[The] Human Body's SensesTheme Pages**
  - Hearing Theme Page
  - Sight Theme Page
  - Smell Theme Page
  - Taste Theme Page
  - Touch Theme Page
- **[The] Human Body's Systems Theme Pages**
  - Brain/Nervous System Theme Page
  - Circulatory System Theme Page
  - Digestive System Theme Page
  - Muscular System Theme Page
  - Respiratory System Theme Page
  - Skeletal System Theme Page
- Oceanography Theme Page

General Life Sciences Resources

Here are a number of links to Internet sites which contain information and/or other links related to Life Sciences. Please read our disclaimer.

For resources on the **Environment**, please see the our curriculum pages on Social Studies

- ## Ask an Expert: Life Sciences

  CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on Life Sciences may be found in our "All Subjects" section at the top of the page, the "Science" section, as well as the general "Reference" section.

- ## AskERIC

  "ERIC" stands for the "Educational Resources Information Center" - a U.S. federally funded national information system that provides a variety of services and products. "AskERIC", the Internet-based equivalent, contains two major components which may be of interest to Science teachers: (1) the AskERIC Q&A service enables teachers to send a message requesting educational information. The Center staff will search the ERIC databases and respond within 48 hours. (2) The AskERIC Virtual Library contains hundreds of lesson plans, access to the ERIC database and ERIC Digests, topical guides to Internet Resources, and archives of education-related listservs.

- ## Biological Timing Online Science Experiment

  K-8 students can participate in two scientific experiments focusing on the concepts of biological clocks by viewing and downloading actual experiments as they are collected at the University of Viriginia. They can then analyse the data, form hypotheses, suggest variables for new experiments, and share conclusions with other students and scientists. Teachers can download background materials.

- ## Biology4Kids

  A site on the basics of Biology with information in the form of text and diagrams on cell structure and function, the chemistry of biology, and how the world of biology is studied, and cell structure and function.

- ## [The] Biology Project

  A wide range of tutorials and online problem sets designed for high school and university biology students by the University of Arizona. Content coverage includes: Biochemistry; Cell Biology; Chemicals & Human Health; Developmental Biology; Human Biology; Immunology; Mendelian Genetics and Molecular Biology.

- ## bioSurf

  Like a biology textbook, this site is organized into units and then into chapters. However, the content in each chapter is a series of links to external web sites which provide the explanatory content. In some cases, these links are to traditional web sites; however, others are to high tech sites where students options range from watching multimedia presentations to manipulating the content (e.g., explore a cell).

- [Birds: A Virtual Exhibition]

  The Royal British Columbia Museum is pleased to bring its collection of bird calls, images and top scientific information to the public through the creation of the Grace Bell Collection Web site. This website is part of a series of "Virtual Exhibits" on Canadian birds being created by museums across Canada, through partnership with the Canadian Heritage Information Network (or CHIN).

- [Bridge: Biology]

  A meta list of links to Biology web sites. Annotated links are organized within approximately 30 categories organized under one of two main headings - Organisms or Habitats.

- [Cell Intelligence]

  Are cells intelligent? In this web site, this question is explored through two lines of reasoning that are explained by text and graphics.

- [Cells Alive]

  A collection of animated gifs and Quick Time Videos of cells of the immune system, bacteria, and parasites. Note: Graphical browser and QT readers required.

- [[The] Froggy Page]

  Everything you wanted your students to know about frogs, including pictures, sounds, tales, songs, scientific information and jokes.

- [From the Ground Up]

  There are five lessons in this teachers' guide on food, agriculture and sustainable development: history of agriculture and description of sustainable development, soil, agriculture and chemicals, the real cost of food, and everything's connected. Available for downloading are lessons, background essays, and worksheets.

- [Fundamentals of Physical Geography]

  Although this online textbook from Michael Pidwirny, Okanagan University College, is intended for postsecondary students studying introductory physical geography, much of it may be applicable for high school students as well. Contents include over two hundred pages of information, more than three hundred 2-D and animated graphics, an interactive glossary of terms, a study guide, links to other Internet resources, and a search engine. See the Table of Contents to directly access such sections as Meteorology and Climatology, Hydrology, Biogeography and Ecology, Geology, and Geomorphology.

- [[A] Future for the Grizzly]

  The B.C. Ministry of Environment, Lands and Parks and 'Orca Bay' (a sports and entertainment information service) have put together a Grizzly Bear web site with an educational focus. You can learn facts about where and how these bears live, find out about the environmental issues that have an impact on them, learn what to do if you should ever encounter one in the wild, investigate the BC Government's Strategy for Preservation and even "ask Dr. Grizz" if you have additional questions.

- Great Plant Escape

  The Great Plant Escape consists of six lessons designed to introduce 4th and 5th grade students to plant science and increase their understanding of how foods grow. The lessons include multidisciplinary activities (math, science, language arts, social studies, music and art).

- Heart Preview Gallery

  This site provides a virtual tour of the human heart. The user can select "things to see" (e.g., movies, diagrams, x-ray images), "things to do" (on-line activities), "things to hear" (beats, murmurs), "things to learn" (teacher resources, activities), and "places to go" (other heart-related sites on the Internet).

- Hidden Killers: Deadly Viruses

  There are four main sections to this web quest site on viruses: Virus Basics (general information); Human Defenses (how our body fights viruses); Virus Profiles (includes histories of some specific viruses); Military (bio-weapons). You'll also find recent news, a conference on viruses, vocabulary, games, and a feature article - all on viruses of course.

- Interactive Frog Dissection

  The Interactive Frog Dissection was designed for use in high school biology classrooms. The intent of this program was for it to be a valuable preparation tool or even a useful substitute for laboratory dissection.

- Microbe Zoo

  Descriptions and explanations of how microbes live in dirt, food, space, animals, and water.

- Multimedia Medical Reference Library

  Geared for medical students, physicians and patients, this site is an incredible reference tool. You'll find a vast amount of information about physical and mental health, diagnoses, medications, nutrition and more.

- Nanoworld Image Gallery

  Microscopic images from the University of Queensland that can be viewed and/or downloaded. Topics include: blood, cellular ultrastructure, digestion, hair, insects, materials, microbes and diseases, parasites, plankton, pollen and spores, reproduction-animals, reproduction-plants, tissues-animals, tissues-plants, and more.

- **New York State Regents Examinations**

  The N.Y. State Regents Examinations are a set of subject-based standardized tests for N.Y. high school students. Here are two resources, from different organizations, that can help teachers and students prepare for these or other similar standardized exams.

  - New York State Education Department Download PDF formatted copies of recent Regents Examinations and answer keys from this page.
  - Regents Exams Prep Centre: Biology The Prep Centre, developed by Oswego County

high school teachers, is intended to help Grade 12 teachers and students prepare for the N.Y. Regents Exams. Teachers can access sets of sample questions that are organized by subject and then by topic. Alternatively, students can attempt the questions, view the correct answer, or follow a link to a tutorial on the curricular content in the question if they need assistance.

- Noah: The Animal Search Engine

  If you're looking for web sites on animals, you can use "Noah" a search engine dedicated to finding such resources.

- [An] On-Line Biology Book

  Modified lectures for freshman-level biology.

- Strange Science: The Rocky Road to Modern Paleontology and Biology

  Today's knowledge about biology and paleontology is often taken for granted. This web site uses historical paintings and images to demonstrate some of the weird ideas that scientists and scholars in these subjects previously held.

- Virtual Frog Dissection Kit

  Disect a frog online! Includes the Virtual Frog Builder game to test your knowledge of frog anatomy.

- [The] Visible Human Project

  Information from the Visible Human Project has been put on the web by the U.S. National Library of Medicine. The project provides anatomically detailed, three-dimensional representations of the human body.

- Worm World

  Advertised as "the yuckiest site on the Internet", Worm World has lots of information for kids about worms. Included are "worms as recyclers", an art gallery, the body parts of a worm, sounds of worms, jokes about worms, and more.

- WWW Virtual Library: Ecology, Biodiversity and the Environment

  A meta-list of links to sites.

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Curricular Resources in Chemistry

Here are a number of links to Internet sites which contain information and/or other links related to Chemistry. Please read our disclaimer.

- Active Learning in Chemistry Education (ALICE)

  Course materials that can be used by high school students/teachers interested in pursuing independent study. There are 29 chapters in the program - each with reading materials, questions to answer, problems to solve, and many laboratory activities to perform. The course material is free upon request and can be printed, photocopied, and given to students one chapter at a time. Caution: This is a Geocities site with intrusive advertising.

- [The] Analytical Chemistry Springboard

  A meta-list of links to sites related to analytical chemistry.

- Ask an Expert: Chemistry

  CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on Chemistry may be found in our "All Subjects" section at the top of the page, the "Science" section (see General Science), as well as the general "Reference" section.

- [The] Biology Project

  Tutorials and online problem sets designed for high school and university biology students by the University of Arizona. Their biochemistry section covers the following topics: basic chemistry, metabolism, enzymes, energy, & catalysis, large molecules, photosynthesis, molecular structure, pH & pKa, and clinical correlates of pH. See also their unit on Chemicals and Human Health

- Chem101

  This WebQuest winner has an online textbook covering seven units (Back to the Basics, Advanced Basics, Chemical Bonding, Periodic Table, Thermodynamics, Solubility & Redox Reactions, and Equilibrium & Acids). Each unit is itself broken down further into sections. There is also a set of 21 chemical labs that students can perform. In some cases the authors provide lab question sheets, which if answered, reveal correct answers. There are also videos showing the lab results in some cases. Caution: navigation through the online textbook is hindered by a reliance on non-descriptive headings however there is a search engine if you wish to go directly to a topic.

- Chem4Kids

  A site on the basics of Chemistry with information in the form of text and diagrams on matter, atoms, elements, reactions and how math is used in chemistry.

- ChemFinder.Com

  A chemical compound database that allows searches to be conducted by chemical name, formula, molecular weight, or CAS Registry Number. These are included in the search results as well as data on melting point, boiling point, evaporation rate, flash point, specific gravity, vapor density, and water solubility. Search results also provide synonyms of the compound as well as a generous set of links to additional information about it on the web. This is a free service but the owners may impose limitations on access if there is excessive use from an address (e.g., a single user or the firewall address serving multi users).

- Chemical Bonding

A unit of study on chemical bonding which includes explanations, lab activities, demonstrations and discussions.

- Chemistry Functions

Students can use this web site to do molar conversions or balance equations. Caution: some instruction in how to use the site may be necessary.

- Chemistry Tutor

Explanations are organized within the following headings: Introduction to Chemistry, Reactions, Grams/Moles Converters, Equations & More, Lab Safety, the Periodic Table. In addition, there is an Ideal Gas Calculator, a Celsius/Fahrenheit Converter, an interactive question & answer page, and links to other pages, including for teachers.

- Chemist's Art Gallery

Contains visualizations and animations of chemistry done at the host site as well as elsewhere on the Internet.

- [The] Chem Team: A Tutorial for High School Chemistry

Study resources for High School and Advanced-Placement Chemistry students.

- CHEMystery

Here's a virtual chemistry textbook written for high school students.

- Department of Chemistry: Educational Aplets

These Java aplets allow students to explore scientific principles through virtual simulations. At the time of review there were six topics: molecules, kinetics, thermodynamics, atmosphere, quantum mechanics, and polymers.

- Eric's Treasure Troves of Science

Extensive on-line encyclopedias of math and science. Included are encyclopedias on the following subjects: Chemistry, Scientific Biography, and Scientific Books. Each section is browsable alphabetically or searchable by keyword. Entries have a concise explanation as well as cross links which can be quite extensive.

- General Chemistry Online

Articles, an ask an expert service, self guided tutorials, and randomly generated quizzes/drills on specific topics are available at this site. Be sure to also check out their collection of links to other chemistry resources on the web.

- Mark's Chemistry Tutor

Explanations of the following concepts: Significant Figures; Dimensional Analysis; The

Mole; Stoichiometry; Limiting Reagent;Aqueous Chemistry; Some Common Types of Reactions; Oxidation Numbers; Redox Equations; Heat and Enthalpy; Quantum Numbers; Electron Configuration; Lewis Dot Structures; and VSEPR.

MathMol (Mathematics and Molecules)

MathMol can provide teachers and students with information about the rapidly growing fields of molecular modeling. It includes multimedia components, a 3 D library of molecular images, a MathMol tutorial for K-12 math or science classroom, on-line activities, and water experiments.

Molecule of the Month

This site has a set of links (one added each month) to information about specific, interesting molecules. At the time of review, there were in excess of 30 links.

New York State Regents Examinations

The N.Y. State Regents Examinations are a set of subject-based standardized tests for N.Y. high school students. Here are two resources, from different organizations, that can help teachers and students prepare for these or other similar standardized exams.

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- Regents Exams Prep Centre: Chemistry The Prep Centre, developed by Oswego County high school teachers, is intended to help Grade 12 teachers and students prepare for the N.Y. Regents Exams. Teachers can access sets of sample questions that are organized by subject and then by topic. Alternatively, students can attempt the questions, view the correct answer, or follow a link to a tutorial on the curricular content in the question if they need assistance.

Oxidation/Reduction

Explanations, exercises and examples of oxidation and reduction concepts.

Ozone to Oilspills

Students from a Princeton University chemistry class have constructed environmental science lessons for middle school students. Topics are chosen from a wide range of environmental issues that lend themselves to chemical explanation. Each unit consists of a series of student lessons/activities. Lesson plans for the teacher are also included. To date, two Princeton classes have been involved and have created two separate projects.

- Spring, 97
  Lessons on Brown fields, Global Warming, Lead, Waste Management, Transportation, and Water Pollution.
- Spring, 98 Lessons on: Energy Production and Utilization, Materials and Recycling, Atmosphere and Air Pollution, Water Pollution and Resources, Food and Toxic Substances.

Periodic Tables Theme Page

This CLN theme page has a small collection of Internet versions of the periodic table. Each provides unique resources in addition to basic information about the elements.

- Physical Science Activity Manual

  This Manual contains 34 hands-on Chemistry & Physics activities that can be downloaded in either MAC (MS WORD) or Windows (Wordperfect) versions. The manual is neither a lab manual nor a series of lesson plans. Rather, it provides the teacher with background information and a collection of student-centered activities which s/he can adapt to local conditions.

- Science Hypermedia Index

  This site can serve as an encyclopedia of Physical Science terms and concepts.

- Virtual Laboratory: Ideal Gas Laws

  Students are able to run three virtual experiments in which they control the action of a piston in a pressure chamber which is filled with an ideal gas. The gas is defined by four states: Temperature, Volume or Density, Pressure, and Molecular Weight.

- Wilton High School Tutorials and Other Things

  Tutorials on about 20 topics in high school chemistry including Stoichiometry, Primary Properties, Oxidation, Balancing Equations, Lewis Dot Structures, Acids and Bases, and more.

- World Wide Web Virtual Library: Chemistry

  This meta-list has links to academic and profit/not for profit institutions; gopher, ftp, and chemistry newsgroups, and world wide announcments in the chemistry field.

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Note: The sites listed above will serve as a source of curricular content in Chemistry. For other resources in this subject area (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Curricular Resources in Physics

Below are the CLN "Theme Pages" which focus on specific topics within Physics. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Bubbles Theme Page
- Electricity (Concepts) Theme Page
- Electronics (Circuitry) Theme Page
- Hot Air Balloons
- Kites
- Magnetism
- Paper Airplanes
- Periodic Tables Theme Page
- Sound

General Physics Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Physics. Please read our disclaimer.

- About Rainbows

  Answers to various questions about rainbows for older students, including: What is a rainbow? Where is the sun when you see a rainbow? What makes the bow? What makes the colors in the rainbow? What makes a double rainbow? and more...

- Amusement Park Physics

  Tell your students that they're going to be learning about conversion of potential energy to kinetic energy, the balance of motion and force, Newton's Third Law of Motion, Galileo's study of falling objects, and the interaction of gravity and weightlessness and you'll receive blank stares. But, you'll get a different reaction if you announce that in their next unit they'll be learning about Amusement Park roller coasters, carousels, bumper cars, free fall and the pendulum rides. Each ride at the site has a brief description of the physics underlying it, an activity or extension (e.g., students design their own rollercoaster), and related links where students can learn more.

- Ask an Expert: Physics

CLN's "Ask an Expert" page has about 100 links to specialists in the field who can serve as a valuable source of curricular expertise for both students and teachers. Questions/answers on Physics may be found in our "All Subjects" section at the top of the page, the "Science" section, as well as the general "Reference" section.

- Energy Matters

  This Think Quest 98 award winning site provides information to students about the different methods of energy production currently in use or in research. In addition, it discusses the history of energy's influence on man, presents how energy is currently being used, and introduces energy from a physics point of view. There's also an interactive game and public message board at the site.

- Eric's Treasure Troves of Science

  Extensive on-line encyclopedias of math and science. Included are encyclopedias on the following subjects: Physics, Scientific Biography, Scientific Books, and Rocketry. Each section is browsable alphabetically or searchable by keyword. Entries have a concise explanation as well as cross links which can be quite extensive.

- How Stuff Works

  This site contains explanations on "how stuff works" for a wide range of objects that we see and use everyday. Categories that are covered include: engines and motors, electronics, around the house, things you see in public, basic technologies, computers and the Internet, digital technology, automotive, current news, food, your body, and miscellaneous. An index and a search engine make it easy to find what you're looking for. Articles are written reasonably clearly and there are plenty of images and pictures to assist in the explanation, but teachers should note that the language level and the use of terminology may put them beyond the ability of younger or beginning science students to understand on their own.

- Index of Educational Documents

  This site can serve as an encyclopedia of Physical Science terms and concepts.

- [The] K-8 Aeronautics Internet Textbook

  This site has a complete text on aeronautics available in various reading levels, lesson plans and activities to help students understand the concepts, and a set of exercises and resources which link the concepts to other subjects (math, language, social studies, performing arts and literature).

- Optics for Kids

  A quick look at some optical basics.

- Physical Science Activity Manual

  This Manual contains 34 hands-on Chemistry & Physics activities that can be downloaded in either MAC (MS WORD) or Windows (Wordperfect) versions. The manual is neither a lab manual nor a series of lesson plans. Rather, it provides the teacher with background information and a collection of student-centered activities which s/he can adapt to local conditions.

- [The] Physics Classroom

Here's a comprehensive set of on-line high school physics tutorials consisting of units, lessons, and sublessons. Contents cover Kinematics, Newton's Laws, Vectors, Momentum, Work, Energy, Power, Circular Motion, Satellite Motion, Einstein's Theory of Special Relativity, Static Electricity, Current Electricity, Waves, Sound Waves, Music, Light Waves,Color, Reflection/Refraction, and the Ray Model of Light. Units contain problems for students to check their knowledge and animated GIFs to teach concepts. In addition to these tutorials, sets of resources that support teaching/learning the concepts can be accessed directly by type, for example: GIF animations and QuickTime movies, problem sets, quizzes, student activities, lab sheets, and projects.

- Physics Internet Resources

Here's a meta-list with links to WWW, Gopher and FTP sites, physics news from around the world, paths to high energy physics sites around the world, astronomy, and even job announcements and conference news round out this site.

- Physics Online

Peter Vogel of Notre Dame Secondary School in Vancouver has developed a site for BC students and teachers. Included are current and back issues of "Physics News" a weekly collection of physics news, tips and strategies for taking scholarship examinations, and various other columns. There are also links to other WWW Physics sites.

- Virtual Labs and Simulations

Here's a collection of links to sites on the web that have computerized simulations of physics principles that allow students to see a visual demonstration of a scientific concept, often in animated form. In addition, the student may be given the opportunity to manipulate one or more variables underlying the concept and then witness the changes. There are close to 300 labs/simulations in senior high physics. Category headings include: Mechanics, Momentum, Rotational Mechanics, Machines, Measurement Tools, Fluid Physics, Electricity, Thermodynamics, Simple Harmonic Motion, Wave Phenomena, Light, Color, Geometric Optics, Astrophysics, and Nuclear.

- [A] Walk Through Time

Here's an illustrated history of time measurment.

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Note: The sites listed above will serve as a source of curricular content in Physics. For other resources in this subject area (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Instructional Materials in Astronomy

Here are a number of links to other Internet resources which contain information and/or other links related to Astronomy. Please read our disclaimer.

- ## AskERIC Lesson Plans - Science: Space Science

  Over 25 lesson plans covering various grade ranges in K-12.

- ## Astronomy Activities

  Over 10 ready-made astronomy lesson plans for teachers of grades kindergarten through high school. The lessons utilized materials that are found in almost every classroom.

- ## Astronomy Lessons

  Over 25 lessons plans, organized by grade level, from the Southeastern Michigan Math-Science Learning Coalition.

- ## Astronomy with a Stick

  Teaching activities for elementary and middle school students intended to help them understand how the relationships between the Sun and the Earth affect changes in daylight hours. The site has three teaching units, each made up of several student activities that can be conducted during daylight hours.

- ## Counting the Stars

  A lesson plan for teaching students a practical technique for counting the stars.

- ## Earth System Science Community (ESSC)

  ESSC is an ongoing NASA funded project with the goal of building an on-line Earth Science curriculum so that teachers and students can investigate the Earth system quickly, easily, and inexpensively. Visit this site for more information about the project as well for the curricula that have been completed.

- ## Encarta Lesson Collection: Astronomy

  Select "Science" and then "Astronomy" on their Lesson Collection Page to find about a dozen lesson plans in this subject.

- ## Exploring Planets in the Classroom

  More than 25 hands-on science activities are provided in classroom-ready pages for both teachers and students for exploring Earth, the planets, geology, and space sciences.

- ## Internet Activities

  Each month, IBM provides a new set of Internet activities focused around a specific theme for a targeted range of grade levels. A number of astronomy units are available. A teacher's guide is included for each topic.

- ## Life in the Universe Curriculum Sample Lessons

  These SETI (Search for Extraterrestrial Intelligence) lessons take advantage of the intense interest that young students have in the existence of extraterrestrial life to motivate their studies of science and other subjects.

- ## NASA Rocket Classroom Activities

  Activities using simple and inexpensive materials that can be used within a science unit about rockets.

- ## New York Times Learning Network

  A variety of Astronomy lesson plans for students in grades 6-12 which use a New York Times article as a starting point.

- ## Outer Orbit

  This site has two distinct sets of instructional materials that teachers will find useful. From their main menu, click on "Lesson Plans" for over 50 such resources, many of which can be used within a multidisciplinary approach. Or, click "In the Classroom" for ideas and examples of what other teachers are doing to bring astronomy into the technology classroom.

- ## Reaching for the Red Planet

  An outline of a 6-8 week course for grade 4-6 students that includes teacher guides, student assignments and experiments, and recommended web resources. The theme of the unit is planning a Mars colony.

- ## Space and Astronomy for Kids: Build an Astronomy Model

  A page of links to sites on the web that have plans for various types of spacecraft models from About.com.

- ## [The] Sun: Power Plant of the Solar System

  This module from the New Jersey Networking Infrastructure in Education Project introduces students to the Sun and its interaction with the Earth. As part of the unit, students use real time data supplied by the Internet to confirm scientists' findings or to come up with their own conclusions.

- ## UC Berkeley Centre forEUV Astrophysics Education Program

  The main attraction in this site for the classroom teacher will be the lesson plans and K12 activities on Earth and Space Science that have been collected. Topics covered by the lessons include: The Electromagnetic Spectrum, Satellite Communications, Satellite Dishes, Constellations and the Zodiac, Solar System Objects, Earthquakes, and More!

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Note : The sites listed above all have lesson plans/activities for the Astronomy classroom teacher. For other resources in this subject area (e.g., instructional materials in General Science, Life Science, or Physical Science), or for curricular content and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Instructional Materials in Geology

Below are the CLN "Theme Pages" which focus on specific topics within Geology. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Air Quality Theme Page
- Avalanches Theme Page
- **Biomes Theme Pages**
  - Antarctic Theme Page
  - Arctic Theme Page
  - Drylands/Deserts Theme Page
  - Temperate Forests Theme Page
  - Tropical Rainforests Theme Page
  - Wetlands Theme Page
- Earthquakes Theme Page
- Floods Theme Page
- Glaciers Theme Page
- Oceanography Theme Page
- Rocks, Minerals, and Mining Theme Page
- Tsunamis Theme Page
- Volcanoes Theme Page
- Water Quality Theme Page

General Geology Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Earth Science. Please read our disclaimer.

- AskERIC Lesson Plans - Science: Earth Science

  There are a number of lessons on geology/earth science within this collection.
- Earth Science Lessons

Over 150 lessons plans, organized by grade level, from the Southeastern Michigan Math-Science Learning Coalition.

- ## Earth Science Lesson Plans

  This University of Cincinnati collection of earth science lesson plans is organized under seven categories: The Earth as a Planet; The Whole Earth; Weather and Climate; Rocks, Minerals and Sediments; Streams, Groundwater, Glaciers and Erosion; Fossils and Earth's History; and Earthscience/Environment. Note that only a few of these lessons are their own; most originate from other organizations such as Big Sky Telegraph, Nebraska, etc. As such, you may find lessons that you've already seen from other links on this CLN page. However, visiting this site is worthwhile because of the size of the collection.

- ## Encarta Lesson Collection: Earth Science

  Select "Science" and then "Earth Science" on their Lesson Collection Page to find over a dozen lesson plans in this subject.

- ## Geology Lesson Plans

  The Nebraska Earth Science Education Network (NESEN) has collected about 25 lesson plans in geology from NESEN teachers.

- ## Grade 12 Provincial Examinations

  Full information on the BC Grade 12 provincial examinations, including exam timetables, exam results, holistic scoring guides, reports to schools and general information. Select "Examinations and Keys (Grade 12 Provincial)" to download previous exams.

- ## Integrated Resource Packages (IRPs)

  These Integrated Resource Packages (IRPs) provide some of the basic information that teachers will require to implement the BC Ministry of Education Science curricula in K-12.

  - Earth Science 11 and Geology 12
  - Science K-7
  - Science 8-10

- ## New York State Regents Examinations

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content in the question if they need assistance.

- [Project Primary]

  Professors and primary teachers have collaborated to produce a set of hands-on activities for the teaching of science. This link goes directly to their section on geology.

- [Science Lab]

  Here's a collection of science experiments that explore various geological concepts within the oil industry. Experiments have a teacher's guide and can be related to informational articles within the site's "Science Watch." Geological topics include collecting data from bore holes, viscosity, buoyancy of drilling fluid, and rock absorbency.

- [Teaching in the Learning Web]

  These educational resources can be used in a multidisciplinary classroom to teach earth science concepts. Included are activities for teaching global change, an interdisciplinary set of materials for grade 7-12 students to learn about maps, and observations for students to learn about faults.

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Note : The sites listed above all have lesson plans/activities for the Geology classroom teacher. For other resources in this subject area (e.g., instructional materials in General Science, Life Science, or Physical Science), or for curricular content and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Instructional Materials in Paleontology

Below are the CLN "Theme Pages" which focus on specific topics within Paleontology. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Dinosaur Theme Page

General Paleontology Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Paleontology. Please read our disclaimer.

- **Access Excellence**

  The following lesson plans on fossils are available in the Access Excellence collection.

  - Fossil Hunt Elementary students gain an understanding of the problem/puzzle solving aspects to putting together a fossil record by having to reconstruct a torn-up paperback book.
  - Paleoanthropology High school students engage in four classroom activities to better understand practical aspects to the study of Paleoanthropology.

- AskERIC Lesson Plans - Science: Natural History

  Six lesson plans on dinosaurs and fossils.

- Earth Science Lesson Plans

  This University of Cincinnati collection has several lesson plans on fossils. There's one lesson at the very top of the page and then a series of links further down under the heading "Fossils and Earth's History."

- Fossils

  In this lesson plan, middle school students simulate what paleontologists do when they discover, excavate and identify a fossil.

- Grade 4 Science Core Unit: Fossils and Rocks

  Within this curriculum guide from Saskatchewan Education, a unit on fossils gives students "another perspective of geologic time, allowing them to examine evidence of plants and animals which existed on the Earth a long time ago."

- Learning from the Fossil Record

  Over 30 sets of cross curricular K-12 classroom learning activities from the Museum of Paleontology at the University of California (Berkeley). In addition to the activities, there is a matrix tying the activities to grades/subjects, as geological time scale, academic articles, and advice on how to tap into the paleontology resources on the WWW.

- No Bones About It

  In this lesson plan, grade 6-12 students use a NY Times article as a starting point to "act as paleontologists, examining pictures of dinosaur skeletons and applying their knowledge of the relationship between skeletal features and survival to create "Paleontology Reports" about their perceptions of the lives of these creatures."

- Set in Stone

  This paleontology site has a number of instructional materials for the teacher. Suggestions for classroom activities can be found in the section titled "For the Classroom."

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Note : The sites listed above all have lesson plans/activities for the Paleontology classroom teacher. For other resources in this subject area (e.g., instructional materials in General Science, Life Science, or Physical Science), or for curricular content and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Instructional Materials in General Science

The WWW sites linked to from this page provide practical assistance for Science teachers wanting to use the Internet as part of their classroom planning/instruction. Some of the sites listed below could be classified as "general science" while others are included on this page because they have resources in more than one of the major science categories (earth and space science, life science, or physical science). Please read our disclaimer.

- ## Academy Curricular Exchange: Science
  - Grades K-5
  - Grades 6-8
  - Grades 9-12

  Science mini lesson plans from Academy One/Columbia Education Center.

- ## Activity Search: Science

  Houghton Mifflin's Education Place Activity Search gives teachers access to a wide number of K-12 traditional (i.e., not Internet) activities. It is possible to search for activities by curriculum areas and/or grade levels, or browse the activities by themes.

- ## Applied Technology Projects

  Lesson plans for over 20 projects for K-7 students in which students learn to apply science linked to BC Curriculum Guides. This site is part of a larger site (Mr. G's Applied Technology Site) that has been developed by Paul Grey of Coal Tyee Elementary School in Nanaimo, B.C.

- ## AskERIC Lesson Plans - Science

  Numerous lesson plans in Agriculture, Biological and Life Sciences, Careers, Earth science, General Science, History, Instructional Issues, Natural History, Physical Sciences, Process Skills, Space Sciences and Technology covering various grade ranges in K-12.

- ## Athena Curriculum

  This web site provides curricular and resource material using geophysical and other data sets acquired via Internet. Included are four folders of resources: Oceans, Weather and Atmosphere, Earth Resources, and Space & Astronomy. A folder might have links to curricular resource materials (e.g., data, other WWW sites) as well as instructional materials for the teacher and/or student.

- ## Barbara's Lesson Plans in Science

  4 science lesson plans for students from K-12.

- ## Bizarre Stuff You Can Make In Your Kitchen

  This site is an ever growing warehouse of the kinds of projects some of the more demented of us tried as young people, collecting in one place many of the classic, simple science projects that have become part of the collective lore of amateur science. It is a sort of warped semi-scientific cookbook of tricks, gimmicks, and pointless experimentation, concoctions, and devices, using, for the most part, things found around the house. These are the classics. Strange goo, radios made from rusty razor blades, crystal gardens... amateur mad scientist stuff. If you happen to learn something in the process, consider yourself a better person for it.

- Cardboard Cognition

A collection of card and board games organized by subject and grade levels (K-College).

- Discover Learning Daybook

From BC Tel and in partnership with CUEBC, the Daybook is a searchable database of BC teacher deveveloped lesson plans. Search by keyword or enter "Science" for over 80 lesson plans in this subject.

- Do It Yourself

Although this part of the CBC4Kids site is really intended for kids, the language and/or concepts in these sections may be too difficult for the target audience to grasp on their own. However, the set of simple experiments using home materials are a good source of demonstrations for teachers. Accompanying each experiment is an introduction and extension information which teachers could adapt for student use as necessary.

- Eduzone: Science and Technology Curriculum K-12

Model daily lesson plans for each of the grades from K-12.

- Encarta Lesson Collection: Science

Select "Science" on their Lesson Collection Page to find about 50 diverse lesson plans in this subject.

- ERIC Clearinghouse for Science, Mathematics, and Environmental Education: Lesson Plans in Science

The ERIC Clearinghouse serves as a metalist of links to Science lesson plans. Some of those lesson plans are already linked to directly from CLN, but there are others that may prove useful.

- Explorer Data Base: Science

The Explorer is a collection of educational resources (instructional software, lab activities, lesson plans ...) for K-12 mathematics and science education." These resources are browsable within broad topic folders or within a curricular framework, or alternatively, you can use a search engine. Several thousand scientific resources are included.

- Fun Experiments

The Southeastern Michigan Math-Science Learning Coalition presents lessons in Science. These can be viewed by subject area or by age of target audience.

- Georgia College EduNet Lesson Plans: Science

Lesson plans on pin-hole cameras and the solar system.

- Healthy School Environment

This interdisciplinary unit will engage middle/junior high school students in participatory science, examination of multi-causal reasons for particular situations, data collection, data organization and data analysis as they conduct field research into the quality of their school environment. The teaching unit is fully developed with lesson plans, assessment guidelines, samples of student work, resource materials, and Internet links. During the project, students will investigate a wide range of school environment issues, including air quality, drinking water quality, temperature, radon levels, carbon dioxide levels, carbon monoxide levels, oxygen levels, formaldehyde content, air flow, illumination, and relative humidity. This is more than a science unit. The teacher developers have integrated the activities to be part of the Social Studies, English, Science, and Math classes in an eight week study.

Helping Your Child Learn Science

This online book was developed by the US Department of Education for parents. However teachers may find the suggestions for interesting children in science useful in the classroom as well. Included in the book are activities for the home and for the community.

Information Technology Lesson Plans Database

This database contains over a hundred lesson plans designed and tested by BC educators for teachers in gradesK-10. The lesson plans integrate Information Technology concepts within traditional subject areas. Use the search engine to find the lessons for a particular subject area. The engine will also allow you to search by grade level, setting (e.g., classroom, lab), time to complete the level, and expertise level.

Integrated Resource Packages (IRPs)

These Integrated Resource Packages (IRPs) provide some of the basic information that teachers will require to implement the BC Ministry of Education Science curricula in K-12.

- Resource Sciences 11 and 12 (Forests)
- Science K-7
- Science 8-10
- Science and Technology 11

Integrating Mathematics, Science and Language

A series of multidisciplinary units (math, science, language arts) for K-3 students from SEDL. Included in each unit is an overview and background information for the teacher, lessons and links to associated web sites on dinosaurs. Units include: K (Five Senses, Spiders, Dinosaurs); Grade 1 (Plants and Seeds, The Human Body, Good Health); Grade 2 (Oceans, Weather, Sun and Stars); Grade 3 (Matter, Sound, Simple Machines).

Inventors and Inventions Theme Page

This CLN "Theme Page" has links to two types of resources related to the study of inventors and inventions. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Knowledge Integration Environment (KIE) Curriculum

Funded by the National Science Foundation and Pacific Bell, this curriculum section contains individual and group projects in K-12 science.

- Kodak Lesson Plans: Science

More than 30 lesson plans on Science, all of which use photography in some respect.

- Learning for a Sustainable Future (LSF): Classroom Activities

Learning for a Sustainable Future is a Pan-Canadian nonprofit organization whose mandate is to work with educators from across Canada to integrate the concepts and principles of sustainable development into the curricula at all grade levels. The above link is to their page of classroom activities.

- Learning Space (LS) Science: WWW Research Lessons

One of the ways to integrate the Internet into your classroom is by using it as a source of current curricular information. Having students conduct research on the WWW is an effective and relevant learning activity but teachers may feel at a loss as to what kind of questions students should be given to research. This site contains over 30 examples of science research questions (organized by grade levels) which pose motivating, genuine problems or open-ended real life problems whose solutions and answers are not easily found. In addition, there is a step-by-step guide to creating your own research questions.

- Lesson Plans for Middle School Science from Goose Hollar

Lesson topics available at this site include: "Surface tension on coins", "What if you ever quit growing?", "How much skin is on the human body?", "The airfoil airplane", and more.

- Lesson Plans for Technology

This site has a database of over 200 technology-based lesson plans developed by Florida educators. Known as T'NT (Technology 'Nformation for Teachers), the site can be searched by grade level, subject, or key word. Lessons allow subject area teachers to incorporate technology within business, computing, fine arts, guidance/health (including safety), language arts, math, science, and social studies subject areas.

- LETSNet: Science Units

LETSNet (Learning Exchange for Teachers and Students through the Internet) is designed to help teachers understand the web and find ways to make effective use of web resources in the classroom. This link is to their Science lesson plans section containing about 10 teaching units or student activities.

- Minnetonka Elementary Science Center

The Science Center is a warehouse-type resource centre for Minnetonka School District teachers. Some of the information on this web site pertain only to the operations of that center. However, there are other electronic resources which will be useful to any elementary science teacher, including lesson plans (organized by grade levels) and teacher tools (e.g., practical suggestions on science fairs).

- MSTI Elementary Lesson Plan Outlines

  Elementary school lessons exploring plants and animals.

- Optical Illusions

  Over 25 examples of optical illusions that teachers can use to stimulate discussion and interest.

- Primary Resources: Science

  Science worksheets, activities and resources for the primary teacher. Some resources are viewed online and others are in PDF format.

- Project Primary

  Professors and primary teachers have collaborated to produce a set of hands-on activities for the teaching of science organized under the headings of botony, chemisty, geology, physics, and zoology. There is also a report on the constructivist perspective on teaching science and the importance of activities within that.

- Reeko's Mad Scientist Lab

  A wide selection of graded (easy, intermediate, advanced) science experiments suitable for the home or classroom. You can link to a sampling from the right side of this home page but be sure to look at the left side panel as well. The button labelled "experiments" will lead you to more than 30 experiements sortable by subject or difficulty level. Also, the home page's left side panel has direct links to about 10 other experiments.

- Science

  This is a meta-list of links to other sites which contain lessons plans, instructional materials, and other materials.

- Science Fair Theme Page

  This CLN "Theme Page" has links to information that will help both students and teachers interested in participating/managing a science fair.

- Science Lesson Plans

  This link will take you directly to a sub-list of links to about 30 science lesson plans. The sector is part of a larger list called "The Lesson Plans Page." The lessons aren't particularly well described so you may waste some time exploring and the ads can be a nuisance; however the direct links to actual lesson plans are probably worth it.

- Science Resource Center

  Labs, demonstrations, and lessons that science teachers can access in Chemistry, Life Science, and Physics.

- Science Tracks

  ScienceTracks contains science activities that teachers, parents, scientists and other role models can do with children at school or at home.

- [Snacks by Subject]

  The Exploratorium offers student activities/experiments in a wide number of scientific topics.

- [Spreadsheets]

  Contributions of spreadsheet ideas for enhancing science instruction.

- [Teachers Helping Teachers: Science]

  The Teachers Helping Teachers web site is a collection of lesson plans submitted by practicing teachers. New lessons are added to a cumulative Science file throughout the school year so be prepared for some long downloads.

- [Teaching Ideas for Primary Teachers]

  Looking for ideas, activities or worksheets for elementary students? You'll find a variety at this site organized under the subject heading of Science. You'll also find a feature titled "Time-Fillers". This is a collection of short activities which can be used within a number of subject areas to fill a few spare moments during the day.

- [Unmixed Messages]

  Unmixed Messages contains samples of hands-on, gender-equitable science activities to captivate girls and boys with science.

- [Whelmers]

  "Whelmers" are science activities and demonstrations that "whelm" students (as opposed to overwhelming them). They are activities that will spark their curiosity - activities that will catch, for a moment at least, the eye and mind of even the most indifferent student. Each month this site provides 5 new whelmers from a book by Steven L. Jacobs.

- [wNet School]

  wNetStation, a public television station in New York, hosts a web site designed for K-12 teachers which contains Internet-based lessons for core science curriculum topics. Student and teacher guides are included with each lesson. At the time of review, the site contained lessons on alcohol addiction, genes, the walrus, cloning, buffaloes and wolves, migration, ants, black holes, water cycle, and space shuttle astronauts.

- [You Can]

  Beakman and Jax provide experiments/activities for kids which teachers can apply to elementary science classrooms.

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Note: The sites listed above all have lesson plans/activities for the General Science classroom teacher. For other resources in this subject area (e.g., instructional materials in Earth Science, Life Science, or Physical Science), or for curricular content and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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Instructional Materials in Life Science

Below are the CLN "Theme Pages" which focus on specific topics within Life Sciences. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- **Biomes Theme Pages**
  - Arctic/Antarctic Theme Page
  - Drylands/Deserts Theme Page
  - Temperate Forests Theme Page
  - Tropical Rainforests Theme Page
  - Wetlands Theme Page
- Endangered Species Theme Page
- Gardening for Kids Theme Page
- Genetics/Biotechnology Theme Page
- **[The] Human Body's SensesTheme Pages**
  - Hearing Theme Page
  - Sight Theme Page
  - Smell Theme Page
  - Taste Theme Page
  - Touch Theme Page
- **[The] Human Body's Systems Theme Pages**
  - Brain/Nervous System Theme Page
  - Circulatory System Theme Page
  - Digestive System Theme Page
  - Muscular System Theme Page
  - Respiratory System Theme Page
  - Skeletal System Theme Page
- Oceanography Theme Page

General Life Science Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Life Science. Please read our disclaimer.

- ## Access Excellence

  This web site provides a collection of biology-related activities and classroom projects developed by teachers. Topics include: allergies, animal phyla, bioethics problems, DNA, endangered species, ethanol production from corn, infectious disease, nutrition, and transgenic plants. In addition, it provides a vehicle for putting teachers in touch with colleagues and scientists for discussions about teaching biology and new developments in the field. Note: "Teachers First" has grouped the lessons in the Access Excellence collection by topic for easier reference. All links are directly to the Access Excellence site.

- ## AskERIC Lesson Plans - Science: Biological and Life Science

  Over 75 lesson plans covering various grade ranges in K-12.

- ## Biology Activities

  Seven biology activities suitable for high school students from Flinn Scientific. Topics are: bones, DNA, respiration/photosynthesis, cells, predator/prey, enzymes, and bacteria.

- ## Biology Lessons

  Over 175 lessons plans, organized by grade level, from the Southeastern Michigan Math-Science Learning Coalition.

- ## Biology Lessons for Prospective and Practicing Teachers

  Lessons requiring simple materials for teaching biology to elementary students.

- ## **Core Knowledge Lesson Plans**

  - Animal Classifications An 11 day unit on the difference between invertebrates and vertebrates as well as an in depth study of the classes of vertebrates. Primary classes explore the basic characteristics of birds, fish, mammals, reptiles, and amphibians.
  - Life Cycles An exploration of the circles of life that surround us daily for primary students. The three week unit examines the four basic steps in the life cycle and reproduction in plants and animals.
  - Life Cycle Study: From Egg to Chick Embryology is the focus of this 4 week unit for primary students who are actively involved in hatching and caring for baby chicks. The life cycles of frogs, moths, and butterflies are also included in the unit.
  - [The] Not So SImple Facts About Simple Organisms Three kingdoms of simple organisms (Monera, Protista, and Fungi) are the focus of study in this 25-30 hour intermediate level unit.

- ## Encarta Lesson Collection: Biological and Life Sciences

  Select "Science" and then "Biological and Life Sciences" on their Lesson Collection Page to find about fifty lesson plans in this subject. Subset collections of this subject (Biology; Botony) are also available.

- ## From the Ground Up

  There are five lessons in this teachers' guide on food, agriculture and sustainable development: history of agriculture and description of sustainable development, soil, agriculture and chemicals, the real cost of food, and everything's connected. Available for downloading are lessons, background essays, and worksheets.

- ## Grade 12 Provincial Examinations

  Full information on the BC Grade 12 provincial examinations, including copies of previous exams and their keys (e.g., Biology), exam timetables, exam results, holistic scoring guides, reports to schools and general information.

- ## Integrated Resource Packages (IRPs)

  These Integrated Resource Packages (IRPs) provide some of the basic information that teachers will require to implement the BC Ministry of Education Science curricula in K-12.

  - Biology 11 and 12
  - Science K-7
  - Science 8-10

- ## Integrating Mathematics, Science and Language

  A series of multidisciplinary units (math, science, language arts) for K-3 students from SEDL. Included in each unit is an overview and background information for the teacher, lessons and links to associated web sites on dinosaurs. Units include: K (Five Senses, Spiders, Dinosaurs); Grade 1 (Plants and Seeds, The Human Body, Good Health); Grade 2 (Oceans, Weather, Sun and Stars); Grade 3 (Matter, Sound, Simple Machines).

- ## Internet Lesson Plans

  Each month, IBM provides a new set of Internet activities focused around a specific theme for a targeted range of grade levels. Life Science topics that have been developed include: Animals (Grades 4-8); Gardening; (Grades 2-5); Forestry and trees (Grades 5-8); Exploring insects and spiders (Grades K-2, 3-5); and, Zoo animals (Grades 1-3). A teacher's guide is included for each topic.

- ## Life Science

  Over 20 brief lesson plans in life science for elementary level students from CanTeach.

- ## New York State Regents Examinations

  The N.Y. State Regents Examinations are a set of subject-based standardized tests for N.Y. high school students. Here are two resources, from different organizations, that can help teachers and students prepare for these or other similar standardized exams.

  - New York State Education Department Download PDF formatted copies of recent Regents Examinations and answer keys from this page.
  - Regents Exams Prep Centre: Biology The Prep Centre, developed by Oswego County high school teachers, is intended to help Grade 12 teachers and students prepare for

the N.Y. Regents Exams. Teachers can access sets of sample questions that are organized by subject and then by topic. Alternatively, students can attempt the questions, view the correct answer, or follow a link to a tutorial on the curricular content in the question if they need assistance.

- New York Times Learning Network

  A variety of Life Sciences lesson plans for students in grades 6-12 which use a New York Times article as a starting point.

- Project Primary

  Professors and primary teachers have collaborated to produce a set of hands-on activities for the teaching of science organized under the headings of botony, chemisty, geology, physics, and zoology. There is also a report on the constructivist perspective on teaching science and the importance of activities within that.

- Science Resource Center

  The Science Resource Center is a web site where science teachers can share ideas. Life Science teachers can access demonstrations, laboratory investigations, teaching tips, and exams from two selections on the main menu (Life Science and Biology II).

- Smile Program Biology Index

  Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has close to 200 lesson plans organized under the following headings: Anatomy & Physiology, Biochemistry, Biology, Botany, Environmental Studies and Ecology, General, Genetics, Microbiology, Zoology, and Miscellaneous. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- Snacks about Life Science

  The Exploratorium offers these activities/experiments to demonstrate life science concepts.

- [The] World Wide Biome Project

  Teachers may wish to use this project to provide students with: 1) a standard method of investigating the biomes in which they live; 2) a way of publishing their scientific findings on the World Wide Web for others to view; 3) a site where they can obtain comparative data from other biomes around the world; and 4) a chance to integrate computer skills with ecological sampling skills.

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Note: The sites listed above all have lesson plans/activities for the Life Sciences classroom teacher. For other resources in this subject area (e.g., instructional materials in Earth Science, General Science, or Physical Science), or for curricular content and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

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About Arctic Animals

- What's happening to polar bears in recent decades? (includes polar bear photograph gallery)
- Arctic Wolves and their prey (includes wolf photo gallery)
- Arctic animals and birds on the land and in the sea
- Arctic Explorer: Wolves, polar bears, muskoxen and more
- Official Arctic National Wildlife Refuge Site
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- Butterflies live in the Arctic tundra
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- Great White Bear - Polar bear web site at PBS
- Arctic Animals links from PBS: Bears, Wolves
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- What is a walrus?
- Photographs of the Arctic and Arctic Animals

- Arctic Wildlife Portfolio from the Smithsonian Arctic Studies Center

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  Sustainability, Economic Development, Resource Management, the Global Economy

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  Exploring the past, Colonization, Euro-American Portrayals, Indigenous Response, Ethnographic Portraits

- **Social Equity and Environmental Justice**

  Struggle over Land Claims, Self-Determination, Resource Utilization, Cultural Identity

- **Museum**

  Art, Photography, and Anthropology

- **Virtual Classroom**

  Syllabus, Overview, Case Studies

Please Note: Arctic Forum has been temporarily removed. Look for its return in the fall.

Updated: August 24, 2004

Smithsonian
National Museum of Natural History

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Arctic Studies Center

The Arctic Studies Center invites you to explore the history of northern peoples, cultures, and environments and the issues that matter to northern residents today. Join us as we excavate arctic sites; support indigenous efforts to preserve cultural heritage; and work with communities and scholars to share the treasures preserved in museum collections and archives.

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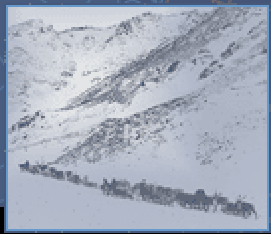

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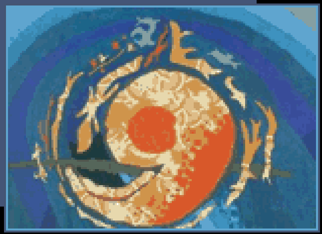

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Arctic Wildlife Portfolio

Tufted Puffin
Photo © Eric Hoberg

Click on a tab to open the portfolio and learn about the animals of the Arctic! Biologist Doug Siegel-Causey shares his knowledge and special insights about this icy world and it's inhabitants.

Are you as smart as an Arctic Fox? Do you have a good memory? To find out, play **Polar Pairs** now.

Meet 19th Century explorer and naturalist **Edward Nelson**.

Spruce up your Arctic vocabulary. Check out the **Glossary**.

From the Editors: We know full well that there are many other animals in the Arctic! If we've missed your favorite, drop us a line... but don't say "penguins." You'll have to travel to Antarctica to see those! We hope to add to this portfolio with new sections including Native perspectives as well as sections on fish, insects and a set of lesson plans for educators. If you would like to submit lesson plans please let us know. Our thanks go out to Douglas Siegel-Causey, Robert Hoffman, William Fitzhugh, Steven Loring and Eric Hoberg.

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Arctic Wildlife Glossary

adaptation - the process of changes in a living organism that help it adjust to the conditions of the environment, making it easier for animals to obtain food or shelter, or protect offspring.

arctic - the area lying above 66 ½ degrees North latitude that includes the Arctic Ocean and lies between North America and Russia.

camouflage - markings or coloration that help disguise an animal so it is less visible to predators or prey.

dominance - the species of plant or animal that exerts the most influence on the community because of its quantity or strength; the ruling animal.

mammal - a class of animals that have backbones, are warm-blooded, breath air, and whose females have milk-secreting glands for feeding their young. There are 19 orders and over 5,000 species of mammals, ranging from the 2 inch shrew to the 100 foot whale.

migration - the movement of animals, fish and birds in search of food or shelter, often on an annual basis according to the seasons.

pack ice - an area of floating islands of ice that form floes a few feet wide to ice islands miles across. These islands drift in the center of the Arctic Ocean and occasionally drift South as far as Newfoundland.

permafrost - any soil in the arctic regions in which temperatures below freezing have existed continuously for a long time.

predator - animals who live by hunting and preying on other animals for their own food supply.

tree line - (also called timber line) the point on mountain or high elevations beyond which no trees grow. The line varies depending on latitude, climate and soil conditions. Also northern boundary of boreal forest.

tundra - a treeless, level or gently rolling plain of the arctic region. It has a marshy surface where mosses, lichens and low shrubs grow with mucky soil and permafrost underneath.

Home | Arctic Wildlife | Birds | Mammals | Sea Mammals | Glossary

Albatross

Bald Eagle

Peregrine Falcon

Ptarmigan

Puffin

Snowy Owl

Click on an animal name to learn more. Click on a tab to see other animals.

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Birds | Mammals | Sea Mammals

[Arctic Fox]

[Caribou & Reindeer]

[Lemming]

[Musk Ox]

Click on an animal name to learn more. Click on a tab to see other animals.

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Polar Pairs

Match up the animals and learn all about their habits and habitat. It might get a little chilly, so keep your nose warm!

(requires a Java enabled browser)

Home | Arctic Wildlife Portfolio

Game by Objective Consulting, Inc. and S2N Media, Inc.

How to Play

Click on the game pieces. Try to match two pictures of the same animal and make a **Polar Pair**! Match the whole board and you win!

Bald Eagle
These "eagle-eyed" birds showed early fishermen where the salmon were swimming.

Polar Bear
These fierce white giants can weigh as much as a car, but you wouldn’t want to ride one.

Caribou
Newborns of these animals can run when they are only 90 minutes old.

Puffin
Flying underwater is no challenge for these hydro-dynamic travelers.

Arctic Fox
This foxy predator trades its blue-grey summer coat for a white one in winter.

Beluga Whale
These sea canaries are real head turners. They use sound to find their prey.

Seal
If your toes pointed backwards like these sea mammals, you might prefer sliding on ice, too.

Walrus
The size of their tusks tells who’s the boss among these sea mammals.

You Won!

Play again and try to beat your best or learn more about these animals and their habitats in the Arctic Wildlife Portfolio!

Beluga Whale

Orca

Polar Bear

Sea Otter

Seal

Walrus

Click on an animal name to learn more. Click on a tab to see other animals.

Biome Investigation

Title:
Biome Investigation

Author:
Ms. Karen Taylor, 5th Grade Science/Math teacher
Email: taylor@aberdeen.k12.sd.us

Subject Matter Emphasis and Level:
Science, math, and technology
grades 4-6

Next Section

Civilization.ca

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SEARCH | ADVANCED SEARCH

QUICK LINKS

FIRST PEOPLES

EXPLORE BY SUBJECT:

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- CIVILIZATIONS
- CULTURES
- FIRST PEOPLES
- HISTORY
- TREASURES
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- EXHIBITIONS
- FEATURES

RESOURCES FOR:

- KIDS
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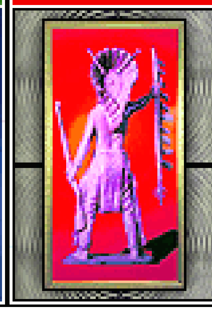
- SCHOLARS
- MEDIA

- PUBLICATIONS
- BOUTIQUE
- THE CORPORATION
- FEEDBACK

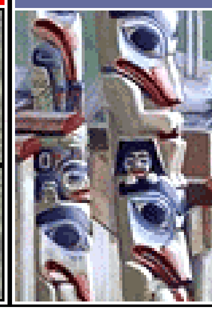
MAIN FEATURES

Native People

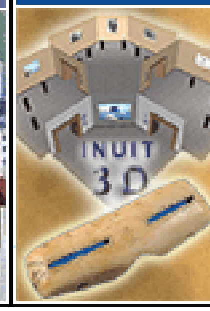
Emergence



The Haida



Inuit 3D



OTHER FEATURES

Legends of Our Times: Native Ranching and Rodeo Life on the Plains and Plateau

This exhibition portrays Native People's involvement in ranching, rodeo and industries related to this lifestyle. It explores the relationship Native People have had with the horse, dog, buffalo, coyote and deer and their transition to becoming cowboys, ranchers and rodeo participants.

From Time Immemorial: Tsimshian Prehistory

European scientific knowledge and Native oral history are woven together in this exhibition to tell the story of the Tsimshian people, who have occupied Canada's north Pacific Coast for over 5,000 years.

Wave Eaters: Native Watercraft in Canada

The watercraft developed by Canada's First Peoples are respected and admired throughout the world for their performance and beauty. This exhibition showcases some of the fine pieces in the Canadian Museum of Civilization's collection and highlights the creativity and skill of Indian and Inuit boat-builders.

Storytelling: The Art of Knowledge

This exhibition illuminates the diversity of, and importance of sharing, narratives in six Native communities: Algonquin, Inuit, Mi'kmaq, Métis-Cree, Nisga'a and Abenaki.

SEE ALSO:

- The First Nations of the New France era
- Grand Hall: Northwest Coast Native culture
- In Memoriam: Bill Reid (1920-1998)
- Stones Unturned
- People of the Salmon
- Threads of the Land: Clothing Traditions from Three Indigenous Cultures
- The Inuvialuit of the Western Arctic: From Ancient Times to 1902
- Where Sea and Land Meet: Historical Northwest Coast Native settings in the art of Gordon Miller and Bill Holm
- Iqqaipaa: Celebrating Inuit Art, 1948-1970
- Moccasins
- "A few things in the way of curios": Historic Ivories at the Canadian Museum of Civilization
- Aboriginal Participation in Canadian Military Service: Historic and Contemporary Contexts
- Canadian Inuit History: A Thousand-Year Odyssey
- Snow Travel in Ancient Canada
- Archaeology
- Selected items from the collection of the Canadian Museum of Civilization
- Other Web sites

Created: *September 27, 2001*. Last update: *July 22, 2002*

About CAFF

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The CAFF Program

Overview

Conserving Arctic
Flora and Fauna

Conserving Arctic Ecosystems
and Habitats

Monitoring Arctic Biodiversity
and Living Resources

Global Issues

Enganging Society

CAFF Documents

Technical Reports

Habitat Reports

Meeting Reports

Organizational Documents

Password Protected Area

CAFF Scientific Databases

AMAP/CAFF Database

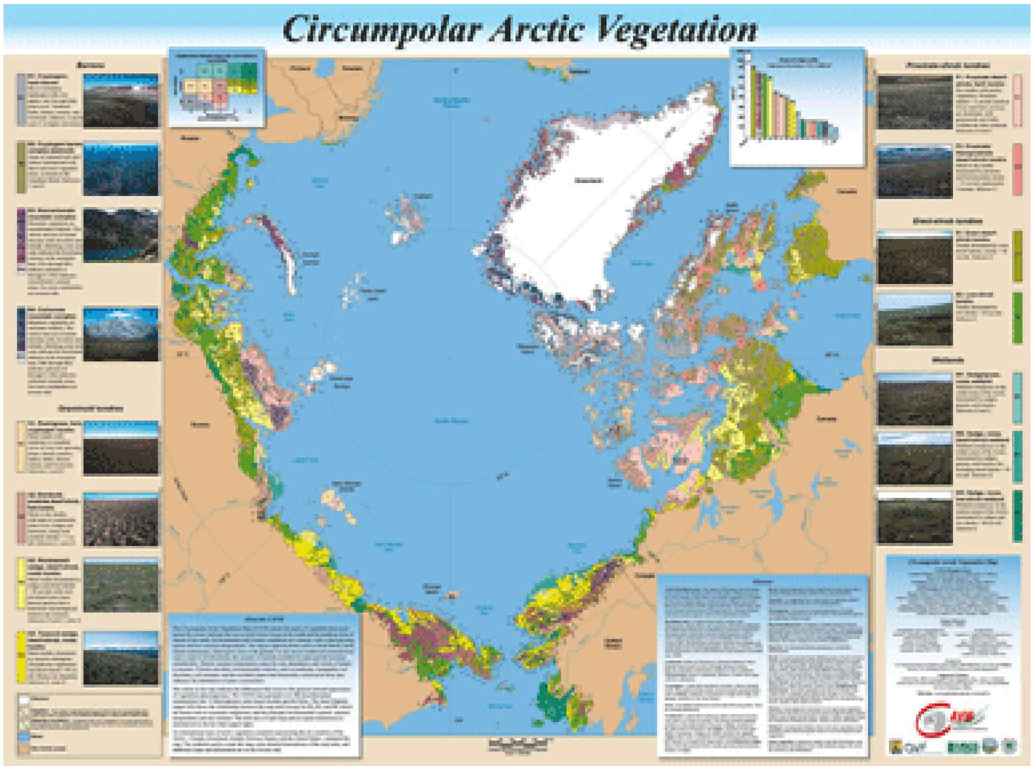
Links

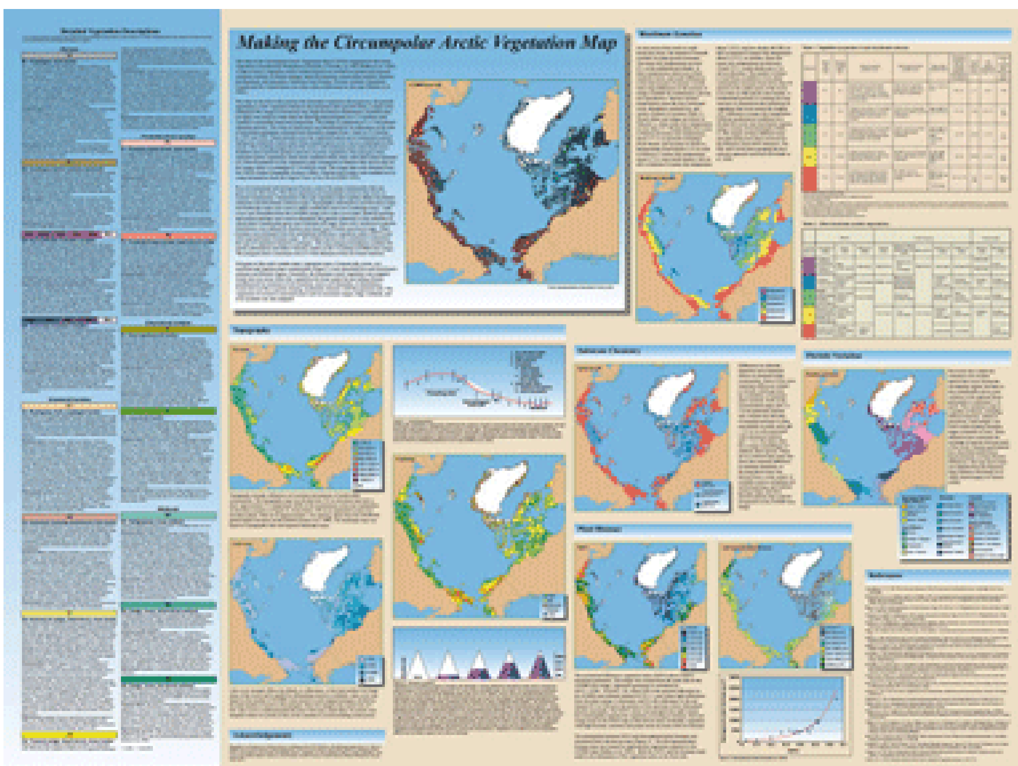
Conservation of Arctic Flora and Fauna (CAFF) is a Working Group of the Arctic Council. It mission is to conserve Arctic biodiversity and to ensure that the use of Arctic living resources is sustainable.

CAFF Map No. 1 - Circumpolar Arctic Vegetation Map

Two types of the 36"x48" map are available: YUPO, a tear-free moisture resistant unfolded rolled-up) map, and a folded glossy map. To obtain a copy, please contact the CAFF

Secretariat.





Search Caff's Website

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News and Announcements

23.2.2004
The ACIA International Scientific Symposium on Climate Change in the Arctic from November ..
23.2.2004
The CAFF X Biennial Meeting will take place from September 14 to 16, 2004 in Anchorage, Al..
23.2.2004
There will be a CAFF Management Board Meeting on April 14, - 16, 2004 in Oslo, Norway. The..
31.1.2004
The CAFF Technical Report 11: The Conservation Value of Sacred Sites of Indigenous Peopl..
22.1.2004
Announcement for CAFF Management Board Meeting in Oslo, Norway from April 14 to 16, 2004..
14.1.2004
Conference Announcement ..
3.7.2003
CPAN and the Canadian Council on Ecological Areas will be jointly sponsoring a two day wor..
31.10.2002
Presentation by Sune Sohlberg, CAFF Chair at Arctic Council meeting in Saariselka, Finla..
17.9.2002
With financial support from the Danish Environmental Protection Agency, a RAIPON/CAFF/IPS ..
All news and announcements

Upcoming Events

3 - 6 Sept 2004
6th Conference of Parliamentarians of the Arctic Region
Nuuk, Greenland
13 Sept 2004
CPAN Meeting in Anchorage, Alaska.
Anchorage,Alaska
14 - 16 Sept 2004
SDWG Meeting
Whitehorse, Yukon, Canada
14 - 16 Sept 2004
CAFF X Biennial Meeting in Anchorage, Alaska.
Anchorage, Alaska.
All Events

caff@caff.is

NOT ALONE ON THE ICE

Designing for Community

No one can survive alone in the Antarctic, and one's companions on that hostile continent become lifelong friends.

-- William Campbell

Young investigators test the insulating properties of various materials while designing a South Pole research station.

Suggested Age Level: 10 through 15

SKILLS

- Researching a Topic
- Problem Solving
- Developing an Investigative Design
- Building a Model

SUBJECT AREAS

- Thermal Energy
- Environmental Science
- Social Science
- Architecture

- Anthropology
- Art
- Mathematics
- Physics

ESTIMATED TIME

- Activity 1. Two 45-minute Sessions
- Activity 2. Eight 45-minute Sessions

Background Activity 1 Activity 2 Suggested Design Teams
Home and Community Connection

Design Connections Table of Contents NOT ALONE ON THE ICE

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NUNATSIAQ NEWS

August 27, 2004

Go!

Armed forces win narrow victory over Nunavut weather

"You can have the best equipment in the world but you can't defeat it"

GREG YOUNGER-LEWIS

The Canadian armed forces came to the Arctic and got what they were looking for - a challenge.

Soldiers participating in Operation Narwhal, the joint military exercise between navy, army and the air force in Panniqtuuq, stumbled through a difficult two weeks around the Cumberland Peninsula, plagued by weather bad enough to ground multi-million-dollar helicopters, and cause two soldiers to get lost in the fog.

FULL STORY

Half-full cruise ship stops in Iqaluit

"What's Nunavut?" cruise line VP asks

SARA MINOGUE

The Clipper Adventurer, a cruise ship run by a St. Louis, Missouri firm, stopped in Frobisher Bay for a couple of hours on Tuesday to let travelers come ashore for a quick tour of Iqaluit, the

News Sections

Nunavut
Armed forces win narrow victory over Nunavut weather

Half-full cruise ship stops in Iqaluit

Good beats, good eats

Senior Rangers critical of armed forces

First Air sues over 2001 hangar fire

NTI to decide on new bank system by November

Have money, will travel: U.S. grant fund eyes Nunavut

Hockey stars convene in Iqaluit

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Amundsen brings health workers to Nunavik

Nunavik faces French teacher shortage

Aqpik jam immortalized in rocker's web log

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ship's only stop in Nunavut.

"We're not contributing to the local economy too much," said John Martens of Cincinnati, Ohio, a self-declared "non-shopper," of the trip, which took him and his wife Karen to the "impressive" tourist's centre, Nunatta museum, and two gift shops.

By noon, passengers were clambering back over the chaotic rocks of Iqaluit's breakwater to get into the Zodiak boats that would take them back to their boat, far out in the bay.

FULL STORY

Berry season in Nunavut: Mina Pearce, 51, found blueberries, blackberries, small cranberries and kala near the gravel pit outside Iqaluit on Aug. 26. "I like picking them," she said. "It clears your mind." (PHOTO BY GREG YOUNGER-LEWIS

Nunavik Junior Rangers camp on James Bay

Around Nunavik
Man drops dead in Kuujjuaraapik

Great Whale River drownings claim two

Young dancers head to Kuujjuaq

Iqaluit
Iqaluit's pedestrian walkway plan unveiled

Around Iqaluit
Parking problem partly solved

Iqaluit goes online

Attempted murder charge laid

Features
Volunteer firefighters go back to school

Around the Arctic
She's still at it

Global warming to hit Europe hard

Ivory smuggler arrested

Alaska sweltered this summer

Poll

What should become the new Nunavut government's most urgent priority?

- (•) Economic development and job creation
- ( ) Housing and homelessness
- ( ) Crime, corrections and the justice system
- ( ) Inuit language and culture
- ( ) Education and training
- ( ) Mental health services and suicide

Vote

This online poll is provided solely for the entertainment of our readers. It reflects the opinions of only those Internet users who have chosen to participate and its results do not necessarily represent the opinions of the public as a whole or the publishers and staff of Nunatsiaq News.

View Results...

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POLAR CONNECTIONS
EXPLORING THE WORLD'S NATURAL LABORATORIES

NATIONAL SCIENCE & TECHNOLOGY WEEK • APRIL 26 - MAY 2, 1998

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Geoguide/nenets
Classroom Ideas: Ninth-Twelfth Grade
brought to you by nationalgeographic.com and Compaq

The Siberian Arctic

OVERVIEW

Each spring groups of Nenets migrate with their reindeer herds from the shelter of the northern forests, the taiga, to the treeless tundra of Russia's Yamal Peninsula 200 miles (312 kilometers) beyond. Their homeland encompasses fragile ecosystems threatened by overgrazing reindeer and the tapping of oil and natural gas reserves.

Have your students explore the ecosystems of northwestern Siberia by studying the region's geography, climate, flora and fauna, and by identifying its food chains. Have them analyze the role reindeer play in this region. Familiarize your students with the threats to the region's biodiversity. Ask your students if other regions of the Arctic are facing the same threats and what is being done to remedy inherent problems.

Connections to the curriculum: natural science, biology, ecology, geography

Connections to the National Geography Standards:

Standard 8: "The characteristics and spatial distribution of ecosystems on Earth's surface"

Standard 13: "How forces of cooperation and conflict among people influence the division and control of Earth's surface"

Standard 16: "The changes that occur in the meaning, use, distribution, and importance of resources"

Standard 18: "How to apply geography to interpret the present and plan for the future"

Time: Three hours or more depending on the depth of your students' research

Materials required are

- copies of the March 1998 NATIONAL GEOGRAPHIC article "Nenets: Surviving on the Siberian Tundra";
- atlases and/or physical maps highlighting vegetation and land use;
- computers with Internet access, if available, for students to review Geoguide/nenets photographs and other sites on Nenets culture (See Resources & Links);
- library for reference materials including books, periodicals, and CD ROMs.

Purpose:

Challenge students to learn about ecosystems and threats to biodiversity.

Students will learn about

- habitats of northwestern Siberia;
- reindeer and their role in biodiversity;
- oil and natural gas reserves and the environmental consequences of tapping these resources;
- threatened regions elsewhere in the Arctic.

SUGGESTED PROCEDURE
Opening:

Assign students to four groups to research the topics: **habitats of northwestern Siberia**, **reindeer**, **oil and natural gas**, and **other threatened regions of the Arctic**. Students can be subdivided into smaller teams with each group investigating the questions listed below. (If students don't have access to the Internet or your library doesn't have sufficient resources about northwestern Siberia, have students study similar Arctic regions in Alaska, Canada, or Scandinavia.)

Development:

Have your students address the following questions as they research their topics.

For habitats of northwestern Siberia:
What is the geography and climate of northwestern Siberia?
What are the habitats and individual ecosystems in this region?
How does climate and geography relate to its natural resources?
What is tundra and taiga?
What is the region's flora and fauna?
What are the growing seasons of the flora?
How long does it take for trees and lichen to grow?
What are the region's food chains?
Where do reindeer fit in the food chain?

For reindeer:
What is the difference between caribou and reindeer?
What do reindeer eat?
Where do reindeer migrate in winter? In summer?
What is the life-cycle of the reindeer?
Is there an overpopulation of reindeer on the tundra?
What are the consequences of overgrazing?

For oil and natural gas:
Where are oil and natural gas deposits in the Yamal?
How is oil and natural gas located?
How are these resources tapped and developed?
How is the environment affected by oil and gas development?
What impact does this development have on reindeer herding and the Nenets way of life?

For threatened regions elsewhere in the Arctic:
What other areas of the world are affected by these issues?
What are people doing to resolve controversies about how natural resources should be used? What are the opposing viewpoints?

As students do their research they may find it helpful to check not only our Resources & Links, but the following related Web sites:

Alaska Department Fish and Game Wildlife Notebook Series
(http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm)

University of Alaska Fairbanks Reindeer Research Program
(http://reindeer.salrm.alaska.edu./index.htm)

Main characteristics of 30 European Landscapes
(http://www.tpesp.es/informe/HTMNF/CH8DOS/TAB0801.HTM)

Beverly and Qamanirjuaq Caribou Management Board
(http://www.arctic-caribou.com/index.html)

The Woodland Caribou: Threatened with Extinction in Canada's Western Provinces
(http://www.afternet.com/~teal/scaribou.html)

Alaska’s Cold Desert
(http://www.blm.gov/education/arctic/arctic.html)

Gas development in Northwest Siberia
(http://www.lib.uconn.edu/ArcticCircle/NatResources/gasdev.html)

Closing:

Teams should report back to their groups. Each group should then appoint a spokesperson to give a brief summary of the group's findings to the entire class. After presentations are made, hold a debate about the use of natural resources on the Yamal. Students should elect a moderator, an environmentalist, oil company executive, government official, Nenets leader. Assign an "advisory board" to each speaker to help him or her prepare for the debate. Use the material from the beginning of the lesson plan to help with supporting arguments.

Suggested Student Assessment

- Have students diagram food chains.
- Groups of students can make a map of the world's Arctic areas and highlight where oil and natural gas reserves are located. Using keys, students can locate areas around the Arctic where these natural resources have been exploited and where the habitats have been severely harmed. Students can make a bar graph to accompany the map naming the exploited regions involved and their approximate acreage.
- Have students write an essay in the form of a short letter to a newspaper editor about environmental threats affecting their region of the country. The letters should be succinct.

Extending the Lesson:

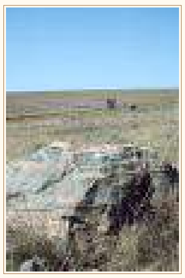
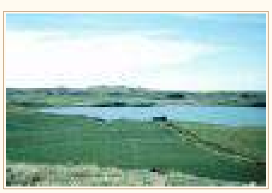
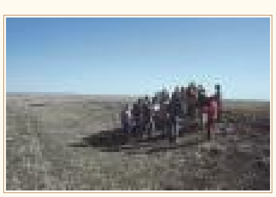
Have students explore habitats close to where they live. Have them study the ecosystems in these habitats. What are the food chains? Are there threats to biodiversity? Are there native peoples in these regions? If so, are their traditional ways of life threatened by development?

Rick Frederic of Nikiski Middle-High School, in Nikiski, Alaska, contributed classroom ideas for this Geoguide.

NORTH DAKOTA STATE UNIVERSITY - FARGO, N D

NDSU HOME PAGE | GEOSCIENCES HOME PAGE | GEOLOGY IN NORTH DAKOTA | FARGO GEOLOGY

GLACIAL FEATURES OF NORTH DAKOTA

	End moraine (Barnes County, N.D.)
	Erratic (Morton County, N.D.)
	Esker (Walsh County, N.D.)
	Esker (Barnes County, N.D.)
	Ice thrust mass (Griggs County, N.D.)
	Ice thrust mass (Burleigh County, N.D.)
	Ice-walled lake plain (Stutsman County, N.D.)

	Kame (Barnes County, N.D.)
	Kettle lakes (Stutsman County, N.D.)
	Meltwater channel (Stutsman County, N.D.)
	Outwash (Barnes County, N.D.)
	Till (Barnes County, N.D.)

[Return to "Geology in North Dakota"]

ICE HOME
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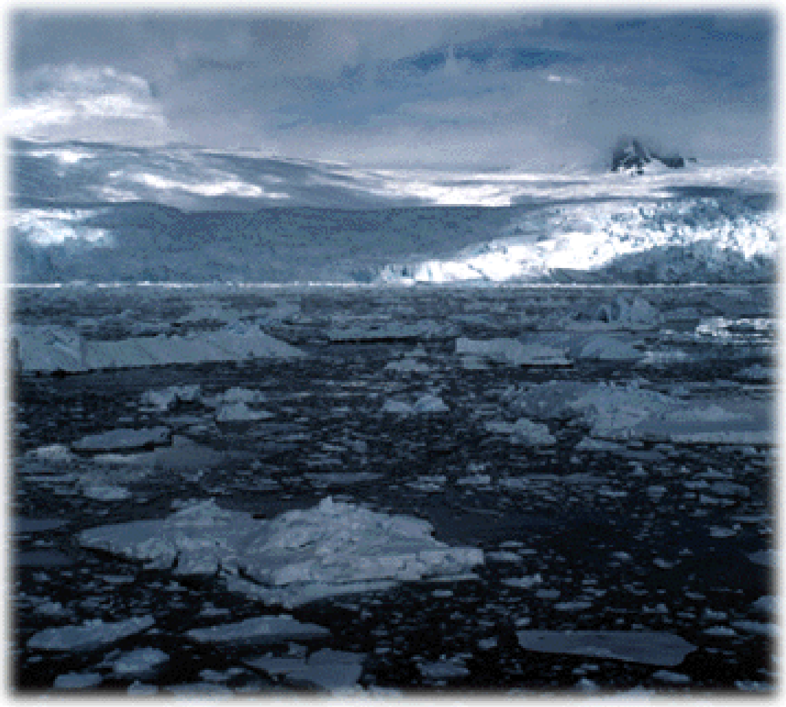
ICE & LANDSCAPE
ICE TODAY
ANTARCTIC ICE
ICE & ENVIRONMENT
WHY ICE AGES?
MEET A GEOLOGIST
BIBLIOGRAPHY
POLAR RESOURCES

Ice sheets have existed on Earth for half of the last one billion years! In the last million and a half years, geologists believe that the ice sheets have expanded to twice the size of today, and then shrunk, more than 20 times!

What causes ice sheets to expand and contract? Are the present ice sheets growing or shrinking? How will global warming impact the ice sheets? How do the ice sheets impact the global system? Glacial geologists study the present glacial environment to understand "ice ages" of the past. Come and explore the ever-changing nature of the glacial setting; the ice, the changes it creates in the landscape, and its response to changes in the environment!



Icy Antarctica holds a warm place in the hearts of glacial geologists. Photograph courtesy of John Anderson, Rice University.

Introduction Expedition Weather Oceans Ice Global Connections

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THE CRYOSPHERE WHERE THE WORLD IS FROZEN

The Cryosphere

The Cryosphere

WHERE THE WORLD IS FROZEN

The word **"cryosphere"** originates from the greek word ***kryos***, meaning frost or icy cold. The cryosphere is the portion of the Earth's surface where water is in a solid form, usually snow or ice. This includes sea ice, freshwater ice, snow, glaciers, and frozen ground (or permafrost).

Cold Facts: Earth's Snow, Ice, and Frozen Soils

Snow

Glaciers

Permafrost

Sea Ice

Cryospheric Trends

Snow
Seasonal snow cover, the largest component of the cryosphere, covers up to 33 percent of the Earth's total land surface. About 98 percent of the total seasonal snow cover is located in the Northern Hemisphere. Although snowdrifts and avalanches often pose hazards to humans, snow also provides much of the world's water. For example, snowfall accounts for 60 to 70 percent of annual precipitation in the U.S. Sierra Nevada and Rocky Mountains, and is later released as water during spring snow melt and river runoff.

Glaciers
Glaciers and ice sheets cover about 10 percent of the Earth's land area. Glaciers, large, thickened masses of ice, accumulate from snowfall over long periods of time. When these ice masses reach a critical thickness, they begin to

All About the Cryosphere
NSIDC EDUCATIONAL SITES

State of the Cryosphere
A scientific synopsis of the cryosphere and climate change. Includes visual snapshots of cryospheric data.

All About Glaciers

move, or flow. A body of ice that covers a large area of land and flows outward in all directions is called an ice cap or ice sheet. Ice caps form in high mountain summit and plateau regions. Two ice sheets exist on Earth now, one in Greenland and one in Antarctica. All continents except Australia bear ice in the form of mountain glaciers, ice sheets, or ice caps. Today, glaciers and ice sheets store about 75 percent of the world's freshwater.

Permafrost

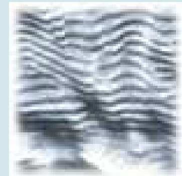
Nearly 24 percent of the exposed land of the Northern Hemisphere contains permafrost. Permafrost prevails over tundra regions and in the Siberian boreal forest. Extensive regions also undergo seasonal freezing and thawing. Because the melting of frozen ground produces unstable surfaces, understanding permafrost is important to civil engineering and architecture in cold regions. Freezing and thawing processes also have a significant impact on ecosystem diversity and productivity.

Sea Ice

Floating ice includes sea ice and frozen lake and river water. Sea ice typically covers 14 to 16 million square kilometers of the Arctic Ocean, and 17 to 20 million square kilometers of the Southern Ocean around Antarctica, during their respective winter seasons. The seasonal cycle of sea ice extent influences both human activities and biological habitats. Many polar mammals, such as penguins, polar bears, and seals, depend entirely on sea ice for habitat. Shipping companies must time navigation activities to coincide with periods of low sea ice concentration.

Since snow and sea ice can influence global climate, and glaciers and ice sheets directly affect sea level, the role of the cryosphere within the global climate system should not be underestimated.

All About Snow, Avalanches, and Blizzards



Antarctic Megadunes

Antarctic Iceshelves and Icebergs

Arctic Climatology and Meteorology Primer

ColdLinks: NSIDC's cryospheric referral center

Cryosphere FAQ

Cryospheric Trends

Because much of the cryosphere occurs in generally remote locations, taking measurements in the field can be both difficult and dangerous. Fortunately, the last several decades have seen the development of increasingly sophisticated satellite technology that has enabled researchers to monitor the cryosphere on a routine basis. In recent years, scientists have discovered striking trends. Satellite data indicate that during the past 30 years, annual snow cover in the Northern Hemisphere and Arctic sea ice extent have decreased at a rate of about 3 percent per decade.

Are these changes part of a natural cycle of climate variability? Or are they a result of human influences on the climate system? These questions underscore the critical need for more cryospheric data and research. For more information, see the State of the Cryosphere.

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The National Snow and Ice Data Center (NSIDC)
Supporting Cryospheric Research Since 1976
CIRES, 449 UCB University of Colorado Boulder, CO 80309-0449
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USGS/Cascades Volcano Observatory, Vancouver, Washington

Glaciers and Glaciations - Ice Sheets, Glacial Lakes, Tuyas - Jökulhlaups and Glacial Hazards

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URL for CVO HomePage is: <http://vulcan.wr.usgs.gov/home.html>
URL for this page is: <http://vulcan.wr.usgs.gov/Glossary/Glaciers/framework.html>
If you have questions or comments please contact: <GS-CVO-WEB@usgs.gov>
08/18/03, Lyn Topinka

Charlotte, The Vermont Whale

Glaciers and the Glacial Ages

The landscape of Vermont, as well as the landscape of much of northern North America, Europe and Russia has been profoundly affected by glaciation over the last 1.5 million years.

- What are glaciers? How do they form?
- What are the physical effects of glaciers? Can these effects be seen here in Vermont?
- How frequently do Ice Ages occur?
- When did the last glacial age end? Will glaciers again advance over North America?

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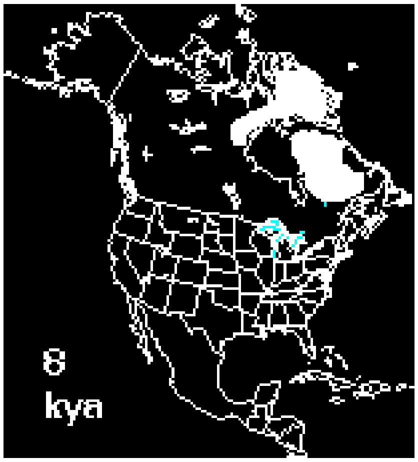
last update April 09, 1996 WAW

Ice Ages



When most people hear the words **Ice Age**, they think of glaciers covering much of North America and Eurasia, animals like mammoths and saber-toothed cats, and Cro-Magnon people painting cave walls. These things come to mind because the words "Ice Age" often refer to the last time that glaciers extended over a large portion of the Earth's surface. The ISM online exhibit The Midwestern U.S. 16,000 Years Ago provides more information on this glaciation in the Midwestern U.S.

The amount of ice on the Earth's surface has varied greatly through time. For example, the extent of ice in North America has changed dramatically since the height of the last glacial advance 20,000 years ago.

During most of the last 1 billion years the globe had no permanent ice. However, sometimes large areas of the globe were covered with vast ice sheets. These times are known as ice ages.

To begin to understand ice ages we must answer the following questions:

- What are Ice Ages?
- When did Ice Ages occur?
- Why do Ice Ages occur?

About this exhibit

Illustrated Glossary of Alpine Glacial Landforms

This module is part of the Virtual Geography Department Project and has been prepared for the Physical Geography Working Group of the project. These materials may be used for study, research, and education, but please credit the author and source: Karen A. Lemke, University of Wisconsin-Stevens Point, and The Virtual Geography Department Project. Linda Freeman, College of the Siskiyous, contributed to earlier versions of this module.

This module has been classroom tested. To make suggestions and corrections, please contact Karen A. Lemke at klemke@uwsp.edu.

Abstract

This module presents basic definitions and examples of common alpine glacial landforms discussed in introductory level university physical geography, geology and earth science courses. Examples are provided as photographs with accompanying topographic maps. The module provides short descriptions of the landforms and identifying features to look for. The combination of photographs and topographic maps should enable users to identify other examples of these features either in photographs, on topographic maps, or in real life. Following the Illustrated Glossary, is an exercise on alpine glacial landform identification so that students may apply what they have learned from reading the glossary.

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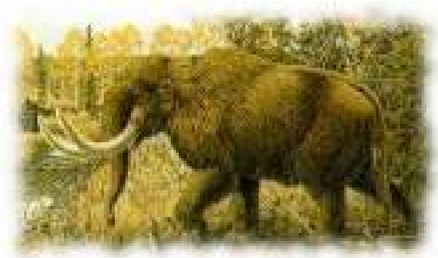
Created June 4, 1997 by Karen A. Lemke & Linda Freeman. Last updated January 17, 2002 by KAL (klemke@uwsp.edu).



The Midwestern U.S. 16,000 Years Ago

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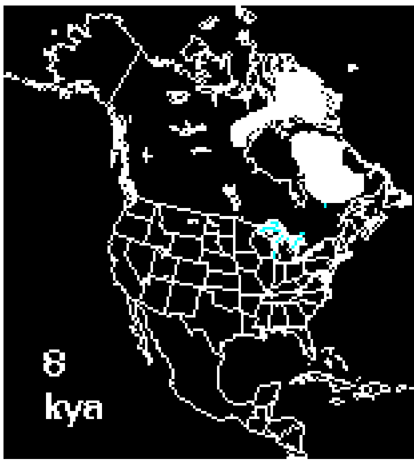
The Retreat of Glaciers in the Midwestern U.S.

18,000 to 6,000 Years Ago



The map shown above is a looping GIF animation of the retreat of glaciers in North America from the last glacial maximum at 18,000 years ago. If your browser supports this type of images, you will see the glacial extent changing on the map.

If your browser does not support this type of animation, you can download an MPEG video showing the retreat or view five maps showing the glacial extent through time.

Both the animations and maps are based on Dyke and Prest (1987).

> *NOTE: the MPEG video is about 216kb* and was created by the ISM GIS Laboratory.

http://www.museum.state.il.us/exhibits/larson/glaciers.html, Last modified January 4, 2002, 10:12AM.

Avalanche Awareness

Contents

Avalanche Awareness:

Surviving an avalanche
A true account

Avalanche Books

Credits & Citations

For more information, see our list of other avalanche sites

1. Why avalanche awareness?

Mountains attract climbers, skiers and tourists who scramble up and down the slopes, hoping to conquer peaks, each in their own way. Yet, to do this they must enter the timeless haunt of avalanches.

For centuries, mountain dwellers and travelers have had to reckon with the deadly forces of snowy torrents descending with lightning speed down mountainsides. Researchers and experts are making progress in detection, prevention and safety measures, but avalanches still take their deadly toll throughout the world.

Each year, avalanches claim more than 150 lives worldwide, a number that has been increasing over the past few decades. Thousands more are caught in avalanches, partly buried or injured. Everyone from snowmobilers to skiers to highway motorists are caught in the "White Death." Most are fortunate enough to survive.

This is meant to be a brief guide about the basics of avalanche awareness and safety. For more in depth information, several sources are listed under "More avalanche resources" in the last section of these pages. They are all well-written, highly recommended publications by knowledgeable avalanche and backcountry experts.

For avalanche classes or instruction, contact a local outdoor equipment store or ski area.

An avalanche in motion. (Photograph courtesy of Richard Armstrong, National Snow and Ice Data Center.)

2. Who gets caught in avalanches?

What is the profile of a typical United States avalanche victim? According to the Colorado Avalanche Information Center, 89 percent of victims are men, most victims are between the ages of 20-29 (although the average victim age is 31), and three-quarters of victims are experienced backcountry recreationists (who are more likely to enter risky situations).

Climbers, backcountry skiers, and snowmobilers are by far the most likely to be involved in avalanches. For a breakdown of activities in relation to avalanche deaths, see the national statistics compiled by the Colorado Avalanche Information Center.

One of the major reasons for increasing avalanche fatalities is the boom in mountain industries and recreation. Skiing, hiking and other winter sports draw millions of people to the mountains. To support these activities, more roads, buildings, and towns are forced into avalanche prone areas.

Backcountry recreationists are most likely to trigger avalanches as they cross hazardous terrain. Non-recreational deaths (such as highway motorists or mountain residents) are often caused when a naturally released avalanche buries buildings or highways.

3. When and where avalanches happen

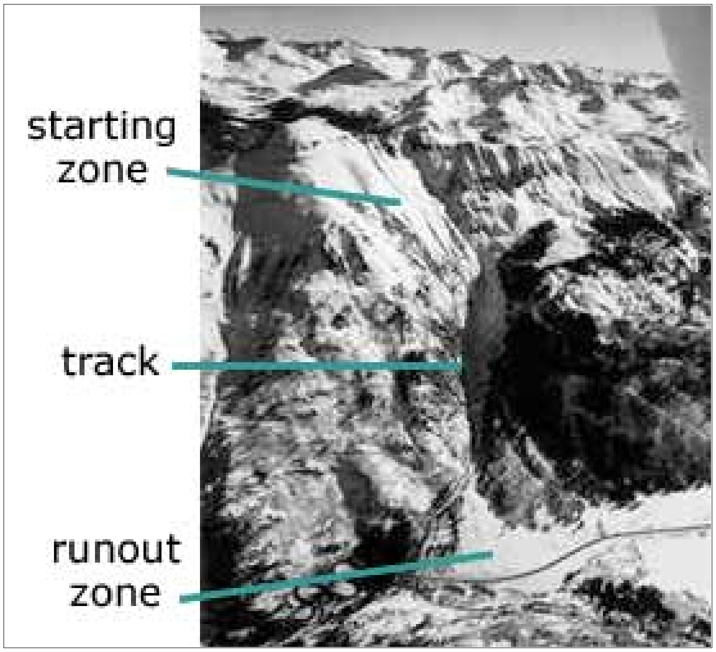
Although avalanches can occur on any slope given the right conditions, in the United States certain times of the year and certain locations are naturally more dangerous than others. Wintertime, particularly from December to April, is when most avalanches will "run" (slide down a slope). However, avalanche fatalities have been recorded for every month of the year.

The highest number of fatalities occurs in January, February and March, when the snowfall amounts are highest in most mountain areas. A significant number of deaths occur in May and June, demonstrating the hidden danger behind spring snows and the melting season that catches many recreationists off-guard. During the summer months, it is often climbers who are caught in avalanches.

In the United States, 514 avalanche fatalities have been reported in 15 states from 1950 to 1997. Colorado has the infamous reputation for being home to about one third of those deaths. Western states account for the majority of fatalities. Northeastern states experience relatively few avalanches in comparison. Arizona's single avalanche death was an out-of-bounds snowboarder killed in 1995. For more information, see the statistics compiled by the Colorado Avalanche Information Center.

While expertise is not a guarantee that you won't be caught in an avalanche, it does provide some basic knowledge about how to avoid avalanche areas, what types of weather and terrain signs to watch for, and what to do if you are caught in an avalanche - all information that may save you or other members of your party.

4. Anatomy of an avalanche



The three parts of an avalanche path: starting zone, track, and runout zone. (Photograph courtesy of Betsy Armstrong.)

All that is necessary for an avalanche is a mass of snow and a slope for it to slide down. For example, have you ever noticed the snowpack on a car windshield after a snowfall? While the temperature is cold, the snow sticks to the surface and doesn't slide off. After temperatures warm up a little, however, the snow will "sluff," or slide, down the front of the windshield, often in small slabs. This is an avalanche on a miniature scale.

Of course, mountain avalanches are much larger and the conditions that cause them are more complex. A large avalanche in North America might release 300,000 cubic yards of snow. That's the equivalent of 20 football fields filled 10 feet deep with snow. However, such large avalanches are often naturally released. Skiers and recreationists are usually caught in smaller, but often more deadly avalanches.

Slab avalanches are the most common and most deadly avalanches, where layers of a snowpack fail and slide down the slope. Since 1950, 235 people in the U.S. have been killed in slab avalanches. Hard slab avalanches involve large blocks of snow and debris sliding down a slope. In soft slab avalanches, the snow breaks up in smaller blocks as it falls.

An avalanche has three main parts. The **starting zone** is the most volatile area of a slope, where unstable snow can fracture from the surrounding snowcover and begin to slide. Typical starting zones are higher up on slopes, including the areas beneath cornices and "bowls" on mountainsides. However, given the right conditions, snow can fracture at any point on the slope.

The **avalanche track** is the path or channel that an avalanche follows as it goes downhill. When crossing terrain, be aware of any slopes that look like avalanche "chutes." Large vertical swaths of trees missing from a slope or chute-like clearings are often signs that large avalanches run frequently there, creating their own tracks. There may also be a large pile-up of snow and debris at the bottom of the slope, indicating that avalanches have run.

The **runout zone** is where the snow and debris finally come to a stop. Similarly, this is also the location of the deposition zone, where the snow and debris pile the highest. Although underlying terrain variations, such as gullies or small boulders, can create conditions that will bury a person further up the slope during an avalanche, the deposition zone is where a victim will most likely be buried.

5. Avalanche factors: what conditions cause an avalanche?

Several factors may affect the likelihood of an avalanche, including weather, temperature, slope steepness, slope orientation (whether the slope is facing north or south), wind direction, terrain, vegetation, and general snowpack conditions. Different combinations of these factors can create low, moderate or extreme avalanche conditions.

Keep in mind that some of these conditions, such as temperature and snowpack, can change on a daily or even hourly basis. This necessitates constant vigilance of your immediate surroundings while doing any wintertime backcountry travel. The route you chose may be safe when you begin, but may become dangerous if conditions change dramatically throughout the day.

While this may seem like a lot of work, once you understand factors that can cause avalanches, most of these signals require simple observation to evaluate your surroundings as they change. Simply ask yourself, when are conditions sufficient to cause a mass of snow to slide down a slope?

The following factors often occur in combination to produce an avalanche, but if a slope is unstable in any way, it may take only the weight of one skier to set off an avalanche. The more foresight you have about conditions and situations to avoid the safer your outing will be.

Weather

Avalanches are most likely to run either during or immediately after a storm where there has been significant snowfall. The 24 hours following a heavy snowstorm are the most critical. Consequently, it becomes important to be aware of current weather conditions as well as the conditions from the previous couple of days. Temperature, wind, and snowfall amount during storms can create fatal avalanche conditions during your outing. If there has been heavy snowfall the day or night before your trip, it may be wise to postpone the trip in order to avoid the increased avalanche danger.

Snowfall

Recent snowfall puts extra stress on the existing snowpack, especially if it does not adequately bond to the pre-existing surface layer. The extra weight of new snow alone can cause a slab to break off and fall down the slope, particularly in storm-induced avalanches. Snowfall amounts of one foot or more (frequent in mountainous areas) create the most hazardous situations, producing avalanches that are often large enough to block highways and cause major destruction. Amounts of six to twelve inches pose some threat, particularly to skiers and recreationists. Amounts less than six inches seldom produce avalanches.

Temperature

Because snow is a good insulator, small temperature changes do not have as much effect on snowpack as larger or longer changes do. For instance, shadows from the sun crossing the snow surface throughout the day will not significantly change snowpack stability. Changes that last several hours or days, such as a warm front moving through, can gradually increase temperatures that cause melting within the snowpack. This can seriously weaken some of the upper layers of snow, creating increased avalanche potential, particularly in combination with other factors.

When temperatures rise above freezing during the daytime and drop back down again at night, melting and re-freezing occurs, which can stabilize the snowpack. This is particularly common during the springtime. When temperatures stay below freezing, especially below zero degrees Fahrenheit, the snowpack may remain relatively unstable.

Wind direction

Wind scouring snow off of the windward side of the peak and depositing it on the leeward side. (Photograph courtesy of Richard Armstrong.)

Wind usually blows up one side of a slope or mountain (the windward side), and down the other (the leeward side). Blowing up the windward slope, wind will "scour" snow off the surface, carry it over the summit, and deposit it on the leeward side. What this does is pack snow unevenly on the leeward side, making it more prone to avalanche. A cornice or icy overhang at the top of a mountain or ridge is a telltale sign of wind scouring. It is safer to travel on the back, or windward side of such a slope, where the snow layer is thinner and wind-packed.

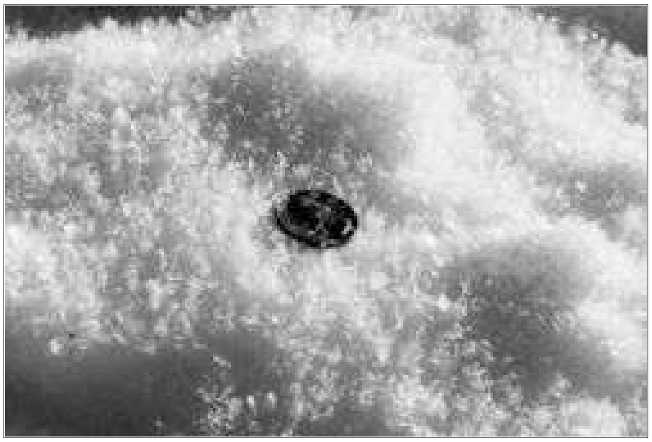
Although it seems like a small amount because the snow may look light and powdery, the weight can add up significantly and can be a critical factor if a slope is already unstable. In the Northern Hemisphere, storms generally move from west to east. Consequently, the leeward slopes are most often the northeast, east, and southeast facing slopes. These slopes become easily wind-loaded and will more readily avalanche. Many ski areas are built on slopes with these orientations and must use prevention measures to counteract the natural avalanche conditions that build up on these slopes.

Snowpack conditions

Perhaps the most significant factor (but not the only one) is how the snowpack has developed over the season. We only see the surface and maybe the top few layers of snow, but it can be layers of snow several feet deep that may ultimately determine whether the slope will fail.

Understanding the history of snowpack for that season can reveal several clues about slope stability. The snowpack as a whole may change not only during the course of the winter season, but throughout the course of a single day, due to changing weather and temperature conditions. This is why constant awareness and frequent slope testing are necessary.

Snowpack conditions are extremely important because many layers of snow build up over the winter season. Each layer is built up under different weather conditions and will bond differently to the subsequent layers. Snowflakes, or snow crystals, within the snowpack eventually become more rounded due to melting/re-freezing and settlement. This metamorphism allows them to compress and (generally) form stronger bonds.



A new layer of surface hoar on the snow. Note the quarter for scale. (Photograph courtesy of K. Williams.)

In between snows, the temperature may rise and melt the exposed surface layers, which when they re-freeze create a smoother, less stable surface for the next snowfall. Failure is much more likely to occur during or after the next few snowfalls. Rain between snows creates a slicker surface as well, and can weaken the bonds between snow layers. On the other hand, light snowfalls and consistently cold temperatures help strengthen the snowpack and make it more resistant to avalanche. Weak layers deep in the snowpack can cause avalanches even if the surface layers are strong or well bonded.

A type of snow called **depth hoar** (a course, grainy form of snow crystal) is often the culprit behind avalanches. Because of its granular structure, similar to dry sand, depth hoar bonds poorly and creates a very weak layer in the snowpack. Unfortunately, the weather conditions necessary to produce depth hoar most often occur very early in the season, and these weak layers are buried under subsequent snows. All too often, deeper depth hoar layers are discovered only after an avalanche has swept off the overlying layers.

Slope angle

Most avalanches occur on slopes between 30 and 45 degrees, but can occur on any slope angles given the right conditions. Very wet snow will be well lubricated with water, meaning it might avalanche on a slope of only 10 to 25 degrees. Very dry or granular snow will most likely avalanche on a slope close to the 22 degree angle of repose. Compacted, well-bonded layers create a snowpack that can cling to steeper slopes until a weak layer is created.

You can measure the slope angle with an inclinometer, or you can "eyeball" it by dangling a ski pole by the strap and estimating the angle. Of course, you may want to practice before using this technique in the backcountry to be sure of your accuracy. Be aware that a single slope can have varying degrees of steepness across its face, depending on the terrain. You may start out on a gentle 25 degree angle, but as you cross, the slope may steepen significantly enough to become an avalanche hazard.

Slope orientation

Although avalanches will run on slopes facing any direction, most avalanches run on slopes facing north, east, and northeast (also the slope directions that most ski areas are located on). Because the sun is at such a low angle, particularly during the winter, a colder and deeper snowpack develops. Slopes that are under shadow throughout most of the day are suspect because the snowpack remains cooler, without much of the melting and bonding that can make the snow layers stronger.

Remember also that certain slope orientations are much more affected by wind-loading, particularly northeast, east, and southeast (similar to the orientations mentioned above). If you are not already familiar with the terrain, taking a compass along would be a good idea. Alternatively, if you know where you are going ahead of time, you could potentially plan your route in such a way as to avoid suspect slope orientations, especially if other potential avalanche factors exist.

Terrain

Paying attention to where you are in the grand scheme of things can offer clues about avalanche likelihood. Bowls and gullies are suspect at any time, regardless of other conditions. Snow can accumulate deeply and quickly in these areas, increasing the possibility of an avalanche. Even if you can see that an avalanche has already run, be wary. Avalanches can fall in a "piecemeal" fashion, where one avalanche will run and leave the rest of the slope weakened, and the slightest provocation can cause subsequent avalanches on that same slope. Smaller depressions or shallow gullies in the mountainside can also be hazardous. During an avalanche, these "terrain traps" serve as accumulation points for snow and debris in which a victim could be buried.

Crossing steep slopes where you may trigger the avalanche yourself should be done cautiously. In contrast, as you cross a valley floor you may also be caught in an avalanche triggered naturally on the steep slope above you. Therefore, during hazardous conditions minimize the amount of time traveling beneath avalanche starting zones and never camp in a potential avalanche runout zone. Even a small avalanche starting high on the slope can carry down large amounts of snow onto and across the valley floor. Remember to keep an eye out for obvious avalanche chutes, where avalanches occur more frequently.

Vegetation

On a snow-covered slope, heavily forested areas are much safer than open spaces, but don't assume that any vegetation at all will be protective. Lone trees, bushes, or large rocks on a mountainside can sometimes weaken the stability of the snowpack. A fracture line (the break-off point for an avalanche) may run from a lone tree to a rock to another tree. Also, during avalanches, trees and rocks catch debris and cause excessive snow pile-up, as well as provide lethal obstacles for anyone caught in an avalanche.

Tree line, above which conditions become too harsh for trees to grow, also plays a significant role in avalanche areas. Many avalanches start above the tree line, making high-elevation mountains especially risky. Although forests help stabilize the snowpack, if an avalanche starts above tree line, it can cut its own path, or chute, through the trees below. Likewise, where there is a swath of trees missing from a forested mountainside (and it's not a ski run), there are probably frequent avalanches running down that particular chute.

Smooth surfaces, such as a rock face or grassy slope, may cause avalanches during the spring melting season. On the other hand, if the vegetation is very low-lying, such as tree stumps or shrubs, it can become buried underneath the first few snows and be relatively ineffective at anchoring the upper layers of the snowpack.

6. How to determine if the snowpack is safe

There are several ways to gauge snowpack stability. Keep any eye out for any cracks shooting across the surface, or small slabs shearing off. These are signs of weakened snowpack. Also, listen for "hollow" or "whumping" noises as you walk or ski. This indicates that there is a weaker layer underneath, leaving the surface layer more prone to collapse. Careful, continuous observations throughout your trip can reveal natural clues, but other more reliable measurements, such as snow pits and shear tests, will help you predict more accurately how stable or unstable the snowpack is.

Snowpits

Digging a snowpit reveals more about the snowpack structure than is visible from the surface. Making a snowpit requires a little more practice and experience, but it is quickly accomplished with a portable shovel. The most effective snowpits should be dug near potential avalanche starting zones, but without putting you or other members of your party at risk. With a shovel, dig a hole four to five feet deep and about three feet wide. Smoothen the uphill wall until it is vertical and you can see the different layers of snow. By pressing your hand against each layer to feel its hardness, you can determine whether there are weak layers.

Shear tests

Once you have dug the pit, a shear test is fairly easy. From the vertical, uphill wall, separate a column of snow without pulling it free from the wall. Insert a shovel at the back (uphill side) of the column and gently pull on the handle. If weak layers pull loose quite easily, the snowpack is very unstable. If it takes a few tugs on the handle before any layers pull loose, the snowpack is slightly unstable. If you really have to pry hard on the handle to loosen any layers, the slope is relatively stable, although caution should still be used at all times.

When conducting these tests throughout the day, pay attention to the slope angle. Layers that seem strong on a 30-degree slope may be much weaker on a steeper slope. Also, remember that the shear test relies on the pull of a shovel, not the weight of a person. You can test this by standing or jumping on the uphill edge of the snowpit (the "banzai jump" test), but only if you already know the snowpack is stable after conducting a shear test and if this presents no risk of injury or of triggering an avalanche.

Snowpit and shear tests should be conducted frequently during your outing, especially if you are crossing several different slopes or types of terrain. Some experts perform them dozens of times a day. While this may seem a bit time-consuming at first, experience will speed the process. More importantly, it is a fairly simple and accurate measure you can make which may save your life.

7. Avalanche gear

Ideally, avoiding avalanches in the first place is much easier than trying to survive one. Avalanche safety begins even before you begin your travel. In addition to keeping an eye out for weather and terrain conditions, there are steps you can take ahead of time to help you or other members of your party if you are caught in an avalanche.

Proper equipment can be a critical factor in rescue efforts. Avalanches kill in two ways. A victim will either endure fatal trauma (collisions with rocks or trees) during an avalanche, or will suffocate after they are buried by snow. While trauma deaths occur before rescue can take place, the more common suffocation deaths are often tragic because with the proper equipment and expertise, they can be avoided.

Portable shovels made of plastic and aluminum are lightweight and compact enough that they can be carried in a pack. Digging with a shovel, as opposed to using hands or ski poles, can dramatically decrease the time it takes to dig out a victim. Digging by hand takes an average of 45 minutes to dig out one square meter of snow. Using a shovel to dig out the same amount of snow takes less than ten minutes.

Collapsible probes or ski-pole probes are also easy to carry along. Collapsible probes usually consist of two-foot lengths of tubular steel that join together to make a probe ten to twelve feet long. Ski-pole probes are made so that grips and baskets can be removed. The two poles can then be joined together to form a probe. Probing is essential to finding a buried victim if there are no visible clues on the surface.

Avalanche beacons (transceivers) are the most commonly used rescue device, and are standard equipment for ski-area patrollers and heli-ski operators. When properly used, they provide the fastest way of locating a victim. When a victim is buried, the transceiver will emit a frequency that other transceivers can home in on. However, it is critical to have the transceiver set to "transmit" during your outing. When trying to locate a buried victim, rescuers will then switch their transceivers to "receive" to locate the signal. Unfortunately, avalanche deaths have occurred due to the fact that the victims had their transceiver switched to "receive" rather than "transmit." Consequently, rescuers could not locate them in time.

Remember that more than one transceiver unit is required. A transceiver will not help locate a victim who is not also wearing one. Likewise, a victim with a transmitting beacon may not be found unless someone else has a transceiver to pick up that signal.

Using beacons requires practice. Homing in on a buried signal involves moving in increasingly smaller circles around the area of the signal. When purchasing a unit, learn how to use it properly, and practice using it frequently. Make sure those in your party carrying transceivers understand how to use them.

Time is of the essence. Carrying this equipment may mean the difference between life and death for someone buried in an avalanche. Statistics show that most survivors are dug out within 15 to 30 minutes. For victims buried longer than 30 minutes, survival chances decrease drastically. In fact, U.S. statistics show that victims buried longer than 45 minutes rarely survive. Depth of burial is also a factor in surviving, but even if a victim is near the surface, the length of time it takes to locate them and dig them out can still be the critical factor.

8. Tips for avalanche survival

Before crossing a slope where there is any possibility of an avalanche, fasten all your clothing securely to keep out snow. Loosen your pack so that you can slip out of it with ease and remove your ski pole straps. Make sure that your avalanche beacon is on and switched to "transmit" rather than "receive." Cross the slope one at a time to minimize danger.

If you are caught in an avalanche

Yell and let go of ski poles and get out of your pack to make yourself lighter. Use "swimming" motions, thrusting upward to try to stay near the surface of the snow. When avalanches come to a stop and debris begins to pile up, the snow can set as hard as cement. Unless you are on the surface and your hands are free, it is almost impossible to dig yourself out. If you are fortunate enough to end up near the surface (or at least know which direction it is), try to stick out an arm or a leg so that rescuers can find you quickly.

If you are in over your head (not near the surface), try to maintain an air pocket in front of your face using your hands and arms, punching into the snow. When an avalanche finally stops, you will have from one to three seconds before the snow sets. Many avalanche deaths are caused by suffocation, so creating an air space is one of the most critical things you can do. Also, take a deep breath to expand your chest and hold it; otherwise, you may not be able to breathe after the snow sets. To preserve air space, yell or make noise only when rescuers are near you. Snow is such a good insulator they probably will not hear you until they are practically on top of you.

Above all, do not panic. Keeping your breathing steady will help preserve your air space and extend your survival chances. If you remain calm, your body will be better able to conserve energy.

Rescuing a victim

Try to watch the victim as they are carried down the slope, paying particular attention to the point you last saw them. After the avalanche appears to have finished and settled, wait a minute or two and observe the slope carefully to make sure there is no further avalanche danger. If some danger does still exist, post one member of your party in a safe location away from the avalanche path to alert you if another avalanche falls.

When traveling with a large party, you may want to send someone for help immediately while the rest of you search. If you are the only survivor, do a quick visual search. If you don't see any visual clues, and you don't have transceivers, then go for help.

Begin looking for clues on the surface (a hand or foot, piece of clothing, ski pole, etc.), beginning with the point where they were last seen. As you move down the slope, kick over any large chunks of snow that may reveal clues. Since equipment and items of clothing may be pulled away from a victim during an avalanche, they may not indicate their exact location, but can help determine the direction the avalanche carried them. Mark these spots as you come across them. Be sure that all rescuers leave their packs, extra clothing, etc., away from the search area so as not to clutter or confuse search efforts.

Once the victim is found, it is critical to unbury them as quickly as possible. Survival chances decrease rapidly depending on how long a victim remains buried. Treat them for any injuries, shock, or hypothermia if necessary.

If you lost sight of the victim early during the avalanche, or if there are no visible clues on the surface, mark where the victim was last seen. Look at the path of the snow and try to imagine where they might have ended up. For those wearing avalanche transceivers, switch them to "receive" and try to locate a signal.

For those using probes, begin at the point the victim was last seen at. Or if you have a good idea of where they were buried, begin in that area. Stand in a straight line across the slope, standing shoulder to shoulder. Repeatedly insert the probes as you move down slope in a line. Pay particular attention to shallow depressions in the slope and the uphill sides of rocks and trees, since these are terrain traps where they may have been buried.

It may be necessary to probe certain areas more than once if you don't locate the victim the first time around, but this takes more time and decreases the victim's chances for survival. Similar to using transceivers, this method of rescue is much more effective if those involved have experience or have practiced finding buried victims using probes.

After searching for clues, or using transceivers and/or probes, still does not reveal the location of the victim, it may be time to rely on outside help. Nearby ski resorts will be staffed with personnel experienced to handle these situations. They will have equipment to locate the victims and dig them out (if your party did not bring shovels or probes), and they may also have avalanche dogs that can help find victims. Ski area patrollers will also have first aid equipment, but unfortunately, by the time they can usually reach out-of-bounds avalanche accidents, too much time has elapsed to save the victim.

9. Avalanche Danger Scale

American and European avalanche danger scales rate avalanche hazard similarly with the exception of using slightly different colors. The differences are noted below.

LOW

Green in both American and European scales:

- Snowpack is generally stable.
- Only isolated areas of instability.
- Backcountry travel is fairly safe.
- Natural or human-triggered avalanches unlikely.

MODERATE

Yellow in both American and European scales:

- Some areas of instability.
- Natural avalanches unlikely; human-triggered avalanches possible.
- Backcountry travel possible with caution.

CONSIDERABLE

Orange in American scale, Ochre in European scale:

- Unstable areas probable.
- Natural avalanches possible; human-triggered avalanches probable.
- Backcountry travel possible with extreme caution.

HIGH

Red in American scale, Orange in European scale:

- Unstable areas highly likely on various slopes and aspects.
- Natural and human-triggered avalanches highly likely.
- Backcountry travelers should avoid steep slopes and wind-loaded slopes.

EXTREME

Black in American scale, Red in European scale:

- Extremely unstable layers in snowpack.
- Natural and human-triggered avalanches are certain.
- Large destructive avalanches probable.

- Backcountry travelers should avoid any steeply angled terrain or known avalanche areas.

10. Avalanche quick checks

Following is a list of quick checks you can make throughout the day:

1. What have the weather conditions been over the past few days? Recent heavy snows?
2. Can you observe any wind loading on the slopes?
3. Do you have a good sense of the snowpack? Have you performed any snowpit or shear tests?
4. Have you noticed many fracture lines, heard "whumping" or cracking sounds, or hollow noises in the snowpack?
5. Are you keeping an eye on the orientation and steepness of the slopes as you cross them?
6. Are you lingering in gullies, bowls, or valleys?
7. Noticed any recent avalanche activity on other slopes similar to the one you are on?
8. If a slope looks suspect, are there alternative routes?

Extra precautions to take

1. If there is no alternative to crossing a suspect slope, do so one person at a time to minimize risk.
2. When descending or ascending a slope, try to stay as far to the sides of a potential avalanche chute as possible to decrease your chances of being caught if an avalanche runs.
3. Be aware of the condition of those in your party. If someone is tired, hungry, or cold they may not be using their best judgement.
4. Remain constantly aware of changing weather or temperature conditions, particularly if your outing will last more than a few hours.
5. Consider avalanche rescue equipment, such as beacons, ski-pole probes, and collapsible shovels, as a necessary part of your backcountry gear.

...Avalanche Awareness...

Try this for avalanche awareness information in German or Italian (as well as English).

Why Worry About Avalanches?

Snow avalanches are a natural process, occurring perhaps 1,000,000 times per year, world-wide. They are one way for snow on an incline to adjust to the pull of gravity. The vast majority of these slides are not a problem, because an avalanche, in and of itself, is not a hazard. A person (or a person's stuff) has to get involved in order for there to be a problem.

What happens if you get caught in an avalanche?

So, who gets caught in avalanches?

The fact is, that avalanches don't drop from the peaks onto the heads of unsuspecting innocents with the unpredictability of a plummeting meteorite. 95% of people who are caught in avalanches are caught by a slide that was triggered by themself or a member of their party.

I think this is good news! If it is our behavior that is creating the hazard, then we can change our behavior to avoid problems.

Avalanche Characteristics

There are many different types of avalanches, but the one that worries us the most is the "slab" avalanche, in which a mass of cohesive snow releases as a unit. This type of avalanche is usually easily recognized by it's distinct crown and flanks (click for a diagram of the nomenclature associated with avalanches).

Slab and other avalanches can be hard or soft, wet or dry and can be triggered naturally or artificially.

Spotting Avalanche Hazard: The Avalanche Triangle

Some place have avalanches: Switzerland's Alps, Utah's LaSals, Nepal's Himalayas. Some places don't: South Viet Nam, the Mile-High Stadium, your living room (the distinctions are not always so obvious, unfortunately).

Why is this?

Avalanches are formed by a combination of 3 things that together are known as the "Avalanche Triangle". These 3 ingredients may be present in one location but absent 10 feet away. The 3 legs of the triangle are Snowpack, Terrain and Weather.

Detecting Instability

There are many tip-offs to the presence of a potential avalanche, including surface clues and active stability tests. You should never trust a single information source--stability evaluation is an ongoing process!

Route Selection & Self-Rescue

The easiest way to rescue yourself is to not get into trouble in the first place.

The best philosophy I can convey about how to avoid problems is the **Principle of the 3 Red Flags** , which states that most accidents are not the result of an unavoidable "karmic-cannonball", but rather are the predictable outcome of a series of related events. The trick to the Principle of the Three Red Flags is to recognize when these events are beginning to stack up and work against you. To do this, you must simply learn to notice the insignificant little details that are the ingredients of significant problems.

Always carry rescue equipment and know how to use it--then pretend you don't have any. Don't get caught in the trap of letting the fact that you are carrying extra gear force you into more dangerous decisions. It's sort of like driving on the freeway: we'd all be a lot kinder and gentler if the driver's seat were lashed to the front bumper instead of encased in a padded steel cocoon.

Use safe route-finding and travel techniques. And remember: if a member of your party is buried by an avalanche, their only real chance of survival is if you rescue them--don't go for help unless you're *sure* they're dead, because they will be by the time you get back with the cavalry.

Putting All The Pieces Together

A question we often get asked is "How do you forecast?". Here are a selection of views and differing methods to help you piece together the Avalanche Triangle which always contains you--the human--as its center piece.

Avalanche Forecasting - A Modern Synthesis by Ed La Chapelle, 1965.
Snow Avalanches: Their Characteristics, Forecasting and Control by Edward R. LaChapelle,1962.
Avalanche Hazard Evaluation Field Checklist by Doug Fesler and Jill Fredston.
How I Forecast for the Back Country by Rod Newcomb.
Safe Skiing - Stop Light Metaphor by Brad Meiklejohn.
Rules Of Thumb by Ron Perla.
Open Book Questions - to encourage reading the ABC's of Avalanche Safety, by Ed LaChapelle.

More Information

You can spend as much time as you wish studying avalanches. I promise that you won't run out of study options--avalanches are not very well understood, the truth be told.

- Frequently Asked Questions about avalanches;

- Upcoming avalanche education in your area;
- Find avalanche study materials here, at the best source of avalanche publication and video reviews and on-line ordering;
- Check the avalanche glossary for explanations of bizarre avalanche terminology;
- Snow and avalanche graduate degree programs in the U.S. and Canada;
- The databases at CRREL and NSIDC reference just about all the research ever done in the field of snow and avalanches, and the Natural Disaster Database Search Engine will never route you to some dippy hockey fan's page when you search with the keyword "avalanche".
- Snow research and snow crystal links.

Other Avalanche-Related Web Sites

- Avalanche.org (West-Wide Avalanche Network) is a grab-bag of useful avalanche information, including avalanche accident statistics, links to avalanche advisories all over the western US, weather links, remote weather telemetry data, an avalanche library and much, much more.
- The Utah Avalanche Center has a new site with links to all the avalanche forecasts in the state.
- Avalanche advisories for mountains outside of Utah.
- E-zines:
  - Firstrax is a Web magazine about Colorado backcountry sports that includes snowpack information pertinent to the La Sals.
  - Couloir Magazine is a great on-line source of information useful for backcountry sports.
  - Mountain Zone is by far the slickest backcountry e-magazine. Look for numerous articles about avalanche awareness topics, avalanche fatalities of the rich and famous, and other mountaineering info.

This site designed and maintained by Faerthen Felix at the Manti-La Sal Avalanche Center.
Send comments, suggestions and field observations to: lsafc@lasal.net

To The

AVALANCHE

DEFENSE PAGE

Created for GE 404, aka, Natural Hazards

under the supervision of Bill Rose

AVALANCHE DEFENSE STRUCTURES AND TECHNIQUES?
The purpose of Avalanche defense is to reduce or eliminate the hazard from potentially destructive Avalanches. Just like there is more than one way to skin a cat, there is also more than one way to keep yourself or others from being squashed by an Avalanche. The purpose of this page is to inform you, the general public, a little about what defensive techniques are out there and how they work.

The majority of defensive systems can be divided into two main groups, active and passive systems. These two options are listed below, along with perhaps the most obvious way to prevent Avalanche damage, that being zoning.

Along with those options there are some links to other Avalanche oriented pages, just in case you were looking for other information about Avalanches, you should be able to find anything you need on the pages listed. Thanks for visitiing this site and let me know what you think! -RHS

- ACTIVE TECHNIQUES -For those who want to rock!

- PASSIVE TECHNIQUES -For those who want to kick back and watch the show.

- ZONING -For those that don't want to deal with Avalanches at all.

- OTHER AVALANCHE LINKS -Some great pages ranging from Avalanche directories to home sites for companies that manufacture Avalance defense structures. Be sure to check these links out!

- MY SOURCES -If you are looking for some extra credit reading material, or really want to know a lot about Avalanche defense and related structures, take a peek at these books!

If you have ANY questions, comments, or ideas pertaining to this page, please email me. My name is Hardy Sawall and I am the joker in charge of this page. Let me know what you think!

Avalanche Dogs! (and more)

More than just snow work...

Search Dog Hasty working in Colorado.
Handler: Patti Burnett.
Photographer: Bob Winsett

Avalanche Dog Training

- Training overview - text and photos **Updated!**
- Training outline from a seminar
- Selected Training photos
- Records of U.S. Avalanche finds by dogs updated February, 2003

General Canine Search and Rescue (SAR)

- Selecting a dog for SAR
- An excellent dog behavior policy
- Training tips
- Reading to consider
- Links to other SAR resources updated February, 2003
- Search pack page
- Working dog humor
- About the author...and a dedication
- SAR-DOGS discussion list FAQ

There's facts about dogs and there's opinions about dogs. The dogs have the facts and the humans have the opinions.

-- L. Allen Boone

Tell us where you're from:

View my Guestmap

<-- The Avalanche Zone -->

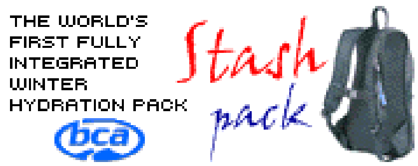
Common
Denominator
HTML
This site is best viewed with ANY browser

Dan Comden
Seattle, WA U.S.A.
Email -- dan*@*comdens.com (remove the asterisks around the "@" symbol)
Updated Feb 14, 2004

www.csac.org - The Avalanche Center

Avalanche Education Center

Please visit, and thank, our Supporters:



Thanks also to our avalanche network, including: Lowepro

We count on people like you to *contribute*. - *Contributions are currently being matched 2:1 !*
The Avalanche Center is a nonprofit organization. You can follow our progress and keep up with what's new by subscribing to our updates list.

Forums Go!

Section Map/Directory

Make the CSAC your "Home"

Search this site Powered by FreeFind

Find!

Search this section only

Welcome to the internet avalanche awareness and education center. This is the place to learn about snow avalanches, avoiding and/or mitigating the risk from avalanches, avalanche resuce beacons, and much more. Learn here and stay safe outdoors!

Educational Resources Online

This page is starting point for all kinds of websites and webpages where you can learn about a wide variety of avalanche-related topics.

HOT
- Spring Avalanche Safety
- Avalanche Danger Scales

Quiz Yourself!

Here are some multiple choice quizes you can take! There is an answer page for each one but to get to it you must follow the link on your results page.

HOT - Spring and Summer Avalanche Quiz

Course Listings and Education Directory

Look here for recreational safety courses and also a listing of people and schools who teach them. If you don't find a course listed which meets your needs consider contacting some of the schools and/or instructors listed for your area.

HOT - *You can now search our course listings by date range, state, and/or type of course!*

The Avalanche Gazette

Formerly in our now-defunct "Other Stuff" section, this publication now reside here. Check out past issues and watch for upcoming ones. Although we did not have time for any issues last season we are hoping for one or two this year.

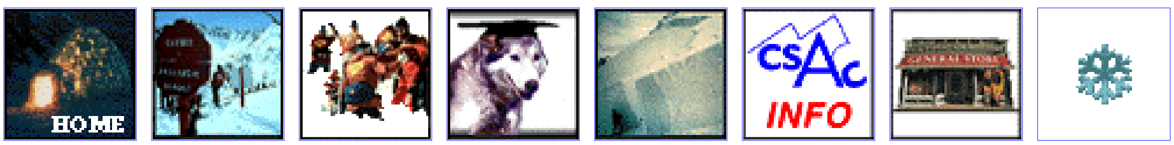
The Avalanche Glossary

Only here on the CSAC website will you find such a comprehensive glossary of avalanche related terms, with well over 200 entries.

Education in the Schools

Suggestions, materials and resources for students and teachers. Course outlines, student web sites and other projects, links to demonstration ideas, ...

Avalanche Research



Providing this resource is not cost free - *Please Contribute!*

Did you sign our Guest Book?

Send mail to the CSAC.

Webmaster: Jim Frankenfield.

discovery.com home

Discovery School discoveryschool.com

Search go!

On TV
Lesson Plans
- Grades K-5
- Grades 6-8
- Grades 9-12

- Astronomy/Space
- Contemporary Studies
- Earth Science
- Economics
- Forensic Science
- Geography
- Health
- History
  - Ancient History
  - U.S. History
  - World History
- Life Science
  - Animals
  - Ecology
  - Human Body
  - The Microscopic World
  - Plants
- Literature
- Mathematics
- Physical Science
- Technology
- Weather

Teacher's Store
Custom Classroom
Teaching Tools
Curriculum Center
Homework Helpers

Favorites
Brain Boosters
Clip Art Gallery
Puzzlemaker
Science Fair Central
Study Starters

Lesson Plans Library 6-8 > Weather

Avalanche!

Grade level: 6-8 | Subject: Weather | Duration: Two class periods

Lesson Plan Sections

Objectives | Materials | Procedures | Adaptations | Discussion Questions | Evaluation | Extensions | Suggested Readings | Links | Vocabulary | Academic Standards | Credit

Printable Version in Rich Text Format

Objectives

Students will understand the following:

1. Friction between snow or rocks and the underlying ground holds the snow or rocks in place on a slope, preventing avalanches and landslides.
2. In order for an avalanche or landslide to occur, friction must be overcome.
3. Substances that overcome friction, causing avalanches and landslides, are called *lubricants;* they include water, ice, and sand.
4. Lubricants make the underlying surface slippery and provide a cushion for snow or rocks to move over.
5. The flatter or rounder the dry lubricant, the more slippery it makes the underlying surface.

Materials

Provide the following materials for each group:

- Old textbook
- Plastic bag
- Half-meter piece of wood about 30 centimeters wide
- Meterstick
- Newspaper
- Tape
- Talcum powder
- Sand
- Pebbles
- Marbles

Procedures

1. Ask your students if they can define the terms *avalanche* and *landslide*. Make sure they understand that in an avalanche deep snow that has been lying on a slope breaks free from the underlying surface and crashes down the slope; a landslide is a similar phenomenon, involving rocks instead of snow. Students should know that both are potentially destructive and dangerous.
2. Ask students to think about the possible causes of an avalanche or landslide. Start them off by asking them to imagine a steep mountainside covered with snow. For weeks, the snow remains on the mountainside without moving. Then, one day, an avalanche occurs. Something must have changed, since things that are stationary do not begin to move for no reason at all. What changes could have caused the avalanche?
3. Tell your students that they are going to perform an experiment that might help them answer the question or confirm the answers that they have formulated. Then divide the class into groups to carry out the experiment.
4. Distribute materials to each group.
5. Have students fold up the newspaper and tape it to the floor to catch any debris.
6. Instruct students to place the piece of wood flat on the floor on top of the paper, and then stand the meterstick with the 0 end down at one end of the board.
7. Next, students should place the book on the board near the meterstick.
8. One student can then slowly lift the end of the board, causing the board to slope, until the book begins to slip.
9. Another student in the group should record the height of the board at the moment the book began slipping down the slope.
10. Have students repeat the experiment after putting talcum powder, then sand, then pebbles, then marbles beneath the book, each time recording the height of the board when the book begins to slip.
11. Discuss with the class the results of the experiment. Can students explain why the book began to slip with the end of the board at a lower level when talcum or other substances were added?
12. Explain that friction between the board and the book held the book in place. The added substances acted as *lubricants,* reducing the friction.
13. Have each student write a paragraph speculating as to what each lubricant used in the experiment may represent in nature. What if the lubricant were water or ice? How would water accumulate under a thick layer of snow on a mountain? They should conclude their paragraphs by telling what they think could have caused the avalanche they imagined before performing the experiment.

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Adaptations

Adaptations for Older Students:
Have students research the causes of avalanches and how avalanches can be predicted.

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Discussion Questions

1. Create a convincing argument for building at least one type of avalanche safeguard for your town. Assume the simplest plan will cost the town one million dollars and there is no money set aside for a project of this magnitude.
2. Develop a plan for how the town will fund construction of the safeguard and share it with the group.
3. Decide who will pay for safeguards around homes outside the central district.
4. After careful discussion, formulate a master plan that seems fair and benefits the majority of the residents.
5. Compare the three types of snow avalanches.
6. Brainstorm and share possible ways people could protect themselves from rock avalanches and pyroclastic flows.

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Evaluation

You can evaluate your students on their reports using the following three-point rubric:

- **Three points:** reasoning carefully thought out; paragraph well organized and error-free
- **Two points:** adequate reasoning; paragraph lacking in organization with some errors
- **One point:** careless reasoning; paragraph lacking in organization with numerous errors

You can ask your students to contribute to the assessment rubric by determining criteria for persuasive reasoning.

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Extensions

Ski Our Mountain, Safest Around
Have students imagine that they manage a ski resort where avalanche barriers around chalets have recently been constructed. Their assignment is to create an illustrated brochure emphasizing safety to lure potential skiers to the resort.

Make a Break
Have your students make their own landslide/avalanche barriers. They will need a piece of wood or thick cardboard to represent a slope, thin pieces of wood for designing barriers, and a pair of dice or game pieces to represent buildings. They can use sand to represent snow or rocks. Instruct students to research avalanche barriers on the Internet and then design barriers of their own. They should place the dice about halfway down the slope without taping or gluing them; then tape or glue different types of barriers on the uphill side of the dice. Have students pour sand down the slope and observe the effects of the barriers, reinforcing them as necessary. Students should evaluate their designs, identifying those that work best, and then compare them with others to choose the best overall design.

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Suggested Reading

Snow Avalanche Hazards and Mitigation in the United States [online book]
National Research Council Commission on Engineering and Technical Systems, 1996
The publisher, the National Academy Press of the National Academy of Sciences, offers full online text with excellent digital imagery of avalanche phenomena.
http://www.nap.edu/readingroom/records/0309043352.html

The Avalanche Handbook
David McClung and Peter Schaerer, Mountaineers, 1993
The intended use of this handbook is a safety manual for hikers and other visitors/dwellers in mountainous regions. From it, much can be learned about the characteristics and behavior of avalanches, in addition to appropriate safety precautions.

“Avalanche!”
Patty Sullivan, Alaska, March 1997
Tom Abell has been buried by avalanches twice. The first time he survived by luck, the second time he was prepared with a homing device.

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Links

Outdoor Action Guide to Winter Camping
Winter camping and hiking basics and precautions. Avalanche safety.

Avalanche Education in the Schools
Somewhat commercial, but a good site! Trying to think of something besides a term paper? Here are some things we have assisted students with.

Avalanche Dogs!
Selecting and training avalanche dogs.

Avalanche Beware!
Facts on avalanches including: recognizing terrain, safety, human factors and rescues.

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Vocabulary

Click on any of the vocabulary words below to hear them pronounced and used in a sentence.

powder avalanche

Definition: A mass of loosely packed snow that begins with a piece of falling rock or ice.
Context: The largest and most destructive is a powder avalanche. A piece of falling ice or rock starts a mass of loose snow sliding down the mountain.

wet avalanche

Definition: A flow of snow, ice, rock, and other material that occurs as a result of thawing.
Context: The second type is a wet avalanche. These occur mostly late in the snow season when the snowpack is deep and the thaw is just beginning.

slab avalanche

Definition: A mass of snow, ice and possibly other material caused when a large slab of snow breaks free from the layers beneath.
Context: A slab avalanche is most deadly. The weight of a skier is enough to break a slab away from the layers beneath.

cornice

Definition: An overhanging mass of snow, ice, or rock usually on a ridge.
Context: Wind can also blow snow into a huge, dense drift or cornice on the crest of a ridge.

pyroclastic flow

Definition: A flow of hot gases, soot, and lava formed by volcanic action.
Context: This gray cloud is one of the most lethal forms of avalanche in the world. It comes out of an erupting volcano. It’s called a pyroclastic flow.

rock avalanche

Definition: A mass of boulders, rocks, and other material that slides down an incline riding on a layer of smaller rocks.
Context: Rock avalanches are the strangest of nature’s forces. Giant boulders “float” on tons of solid rock.

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Academic Standards

This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

Grade level: 6-8
Subject area: science
Standard:
Understands basic Earth processes.
Benchmarks:
Knows how land forms are created through a combination of constructive and destructive forces (e.g., constructive forces such as crustal deformation, volcanic eruptions, and deposition of sediment; destructive forces such as weathering and erosion).

Grade level: 6-8
Subject area: science
Standard:
Understands basic Earth processes.
Benchmarks:
Knows factors that can impact the Earth's climate (e.g., changes in the composition of the atmosphere; changes in ocean temperature; geological shifts such as meteor impacts, the advance or retreat of glaciers, or a series of volcanic eruptions).

Grade level: 6-8
Subject area: science
Standard:
Understands basic concepts about the structure and properties of matter.
Benchmarks:
Knows that atoms often combine to form a molecule (or crystal), the smallest particle of a substance that retains its properties.

Grade level: 6-8
Subject area: science
Standard:
Understands the nature of scientific inquiry.
Benchmarks:
Establishes relationships based on evidence and logical argument (e.g., provides causes for effects).

Grade level: 6-8
Subject area: science
Standard:
Understands the nature of scientific inquiry.
Benchmarks:
Knows that scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists (e.g., reviewing experimental procedures, examining evidence, identifying faulty reasoning, identifying statements that go beyond the evidence, suggesting alternative explanations).

Grade level: 6-8
Subject area: science
Standard:
Understands the nature of scientific inquiry.
Benchmarks:
Knows possible outcomes of scientific investigations (e.g., some may result in new ideas and phenomena for study; some may generate new methods or procedures for an investigation; some may result in the development of new technologies to improve the collection of data; some may lead to new investigations).

Grade level: 9-12
Subject area: science
Standard:

Understands the nature of scientific inquiry.
Benchmarks:
Understands the use of hypotheses in science (e.g., selecting and narrowing the focus of data, determining additional data to be gathered; guiding the interpretation of data).

Grade level: 9-12
Subject area: science
Standard:
Understands the nature of scientific inquiry.
Benchmarks:
Designs and conducts scientific investigations by formulating testable hypotheses; identifying and clarifying the method, controls, and variables; organizing and displaying data; revising methods and explanations; presenting the results; and receiving critical response from others.

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Credit

Frank Weisel, science teacher, Tilden Middle School, Rockville, Maryland.

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Previous Season Avalanche Accidents

2002-2003 US & CANADA, AVALANCHE FATALITIES & CLOSE CALLS

USA Fatalities: **30**

Canada Fatalities: **28**

Total Fatalities: 58

Date	Place	Fatalities	State	Country	Activity	Summary
05-25-2003	Meadow Mountain area about 35 miles north of Kaslo	0	BC	CANADA	SNOWMOBILE	14 snowmobilers caught, carried, 5 buried, 3 injured
04-26-2003	Charity Valley in Alpine County	1	CA	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
04-18-2003	near Crowsnest Pass	1	AB	CANADA	SNOWMOBILE	1 snowmobiler caught and killed
04-15-2003	Devil's Thumb on the Alaska-BC Boarder	2	AK	USA	CLIMB	2 climbers missing and presumed killed in avalanche
04-10-2003	Verde Peak area in the Chugach Mountains	1	AK	USA	SKI	1 skier caught, buried, and killed
04-07-2003	10 km northwest of Golden, BC	1	BC	CANADA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
03-31-2003	Scallop Mountain, near Takla Landing	1	BC	CANADA	SNOWMOBILE	2 snowmobilers caught, 1 buried and killed
03-29-2003	Granite Mountain, near Snoqualmie Pass	0	WA	USA	SKI	1 skier caught, partly buried, seriously injured
03-27-2003	Brewer Creek area, southwest of Invermere	1	BC	CANADA	SNOWMOBILE	12 snowmobilers caught, unknown number buried, 1 killed
03-26-2003	Mountains near Fernie, BC	3	BC	CANADA	SNOWMOBILE	7 snowmobilers caught, 3 buried and killed
03-26-2003	Mount Terry Fox near Valemount	1	BC	CANADA	SKI	1 skier caught, buried, and killed
03-22-2003	North of Burro Peak and south of Bear Creek	1	CO	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
03-20-2003	Ram Mountain Range, southwest of Onion Lake	1	AB	CANADA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
03-20-2003	Porcupine Peak, Loveland Pass	1	CO	USA	SKI	2 skiers caught and carried. 1 injured, 1 killed
03-17-2003	Grizzley Bowl Area in Kokanee Glacier Provincial Park	2	BC	CANADA	SKI	3 skiers caught and buried, 2 killed
03-14-2003	Lake Agnes, northwest of the Fairmont Chateau Lake Louise	1	AB	CANADA	SNOWSHOE	1 snowshoer caught, buried, and killed
03-13-2003	Sheep Pass in the Salt River Range	0	WY	USA	SNOWMOBILE	3 snowmobilers caught, carried, 1 injured, 1 buried and rescue with transceiver
03-12-2003	West of Marias Pass, MT; US HWY 2	0	MT	USA	OTHER	Large avalanche cycle along highway and railroad corridor
03-09-2003	Mount Abundance,10 miles northwest of Cooke City	1	MT	USA	SNOWMOBILE	3 snowmobilers caught, 2 buried, 1 killed
03-09-2003	Ptarmigan Lake, Cottonwood Pass, Sawatch Range	1	CO	USA	SNOWMOBILE	1 Snowmobiler Caught, Buried and Killed

03-07-2003	Backyards, a Permanently Closed Area	0	OR	USA	SNOWBOARD	1 snowboarder caught, buried, and rescued with avalanche transceiver
03-05-2003	Hancock Pass, North of Monarch Pass	1	CO	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
03-01-2003	Microdot Peak, Hatcher Pass	0	AK	USA	SKI	1 skier caught, carried, partially buried & injured. 2 caught in powder blast.
02-24-2003	Smiths Fork in the Salt River Range	1	WY	USA	SNOWMOBILE	1 snowmobiler caught buried and killed
02-22-2003	Near Keokee Lake, northwest of Schweitzer Mountain Resort	1	ID	USA	SKI	1 backcountry skier caught buried and killed
02-22-2003	Echo Bowl near Priest Lake	1	ID	USA	SNOWMOBILE	5 snowmobilers caught, 1 buried and killed
02-22-2003	Mt Belford in the Sawatch Range west of Buena Vista	1	CO	USA	SKI	3 Skiers Caught, 2 Partly Buried, 1 injured (frostbite) and 1 Buried and Killed
02-17-2003	Peak 13,294 (Citadel), Dry Gulch, Loveland Pass area	1	CO	USA	CLIMB	2 climbers caught, carried. 1 buried and killed
02-15-2003	4.5 miles east of Mile 219.5 of the Parks Highway	0	AK	USA	SNOWMOBILE	1 snowmobiler caught and critically injured
02-15-2003	Gobbler's Knob Area	1	UT	USA	SKI	unknown number caught, 1 buried and killed
02-10-2003	Teton County, Hourglass Couloir, a Permanently Closed Area	1	WY	USA	SKI	2 skiers caught, carried, 1 skier buried and killed
02-09-2003	Hatch Peak, above pass to Willow	1	AK	USA	SNOWBOARD	2 snowboarders caught, carried, 1 buried and killed
02-02-2003	Elk Creek drainage of the Crazy Mountains near Livingston Montana	1	MT	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
02-01-2003	Mount Cheops; Rogers Pass area of Glacier National Park	7	BC	CANADA	SKI	17 Skiers caught, 15 buried, 7 killed
02-01-2003	Copper Creek Bowl northeast of Lincoln, MT	1	MT	USA	SNOWMOBILE	2 snowmobilers caught and buried, 1 rescued with transciever, 1 killed
01-29-2003	Avalanche Bowl, Teton Pass	1	WY	USA	SNOWBOARD	1 solo snowboarder caught, buried, and killed
01-25-2003	Kettle Creek Drainage near Togwotee Pass	1	WY	USA	SNOWMOBILE	2 snowmobilers caught, 1 killed , 1 injured
01-22-2003	North side of Wolverine Peak	1	MT	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
01-20-2003	Durand Glacier, near Revelstoke, BC	7	BC	CANADA	SKI	11 skiers caught, 1 injured, 7 killed
01-06-2003	Cardiac Ridge Area in Cardiff Fork	0	UT	USA	SKI	1 skier caught, buried, and rescued with avalanche transceiver
01-05-2003	North of Sheep pass, possibly near Corral Creek Lake	1	WY	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed.
01-05-2003	Near the Red Mountain ski resort	1	BC	CANADA	SKI	1 out of bounds skier caught buried and killed
01-04-2003	Darby Canyon	0	ID	USA	SNOWMOBILE	1 snowmobiler caught, carried, and injured
01-04-2003	near Ski Lake on Teton Pass	1	WY	USA	SNOWBOARD	1 snowboarder caught, carried, and killed
12-29-2002	Norse Peak, near Crystal Mtn. Resort	1	WA	USA	SKI	7 skiers caught, 6 partially buried, 1 injured, 1 buried and killed.
12-28-2002	South of Valemount	1	BC	CANADA	SNOWMOBILE	3 snowmobilers caught and buried. 1 snowmobiler killed
12-28-2002	Trinity Mountain area, west of Fairfield	1	ID	USA	SNOWMOBILE	2 snowmobilers caught and buried, 1 killed
12-28-2002	COOKE CITY	0	MT	USA	SNOWMOBILE	4 seperate snowmobile incidents, one with serious injuries
12-26-2002	West side of the Snowy Range	1	WY	USA	OTHER	1 snowmobiler buried and killed

12-19-2002	Steve Baugh Bowl , Jedediah Smith Wilderness	0	ID	USA	SKI	1 skier caught, buried, and rescued with avalanche transciever
12-15-2002	East of Mt Rose	1	NV	USA	SNOWBOARD	1 snowboarder caught and killed
12-14-2002	Central Idaho	0	ID	USA	SKI	2 backcountry skiers caught and buried in seperate accidents
11-29-2002	Tuckerman Ravine	2	NH	USA	CLIMB	7 climbers caught, 4 buried, 2 killed
11-11-2002	Jackson Hole area	0	WY	USA	SKI	2 backcountry skiers caught and buried in seperate accidents

2001-2002 US & CANADA, AVALANCHE FATALITIES & CLOSE CALLS

USA Fatalities: **35**

Canada Fatalities: **13**

Total Fatalities: 48

Date	Place	Fatalities	State	Country	Activity	Summary
06-13-2002	Denali National Park - Mount Foraker; Southeast Ridge	3	AK	USA	CLIMB	3 climbers, believed to be caught, carried, and killed
04-15-2002	Twin Lakes, Kenai Peninsula	0	AK	USA	OTHER	At least 143 Caribou killed in slide that occured 12/23/2002
04-14-2002	1 mile outside of Fortress Mountain Resort Boundaries	2	AB	CANADA	SNOWBOARD	3 snowboarders caught, 1 injured, 2 buried and killed
03-31-2002	Mount Magnificent, Eagle River area	2	AK	USA	SNOWSHOE	3 snowshoers caught, 2 buried and killed
03-28-2002	S.Fork Eagle River	0	AK	USA	SKI	1 caught, buried, and rescued ALIVE, wearing an avalanche transciever
03-22-2002	East Fork of Targhee Creek	1	ID	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed wearing a transciever.
03-21-2002	Jackson Peak, 6 miles east of Jackson, Wyoming	1	WY	USA	SKI	1 skier caught, buried, and killed
03-18-2002	Dogtooth Mountain Range, outside Kicking Horse Mtn. Resort	1	BC	CANADA	SKI	1 skier caught, buried, and killed.
03-17-2002	Pagoda Peak, 36 miles SW of Steamboat	1	CO	USA	SNOWMOBILE	1 snowmobiler caught buried and kille
03-16-2002	East Face of Pioneer Peak	2	UT	USA	SNOWBOARD	3 snowboaders caught, 2 buried and killed
03-16-2002	South Canyon Creek area, North Fork of the Flathead	1	MT	USA	SNOWMOBILE	2 snowmobilers caught and buried, 1 killed wearing an avalanche transciever
03-15-2002	Temptation Bowl to the East of the Telluride Ski Area	1	CO	USA	SNOWBOARD	2 out-of-area snowboarders caught, 1 seriously injured,and 1 presumed buried
03-15-2002	Banana Chutes, backcountry terrain by Big Mtn. Resort	0	MT	USA	SKI	1 skier caught, buried, and rescued alive
03-14-2002	Strawberry Gulch, East of Aspen Mountain	1	CO	USA	SKI	1 skier caught, buried, and killed.
03-14-2002	East of the Lindley Hut, approximately 4 miles south of Ashcroft	1	CO	USA	SKI	5 backcountry skiers caught, 3 partly, buried, 2 injured, and 1 buried killed
03-12-2002	Grove Creek, near Victor	1	ID	USA	SNOWMOBILE	1 snowmobiler caught buried and killed
03-09-2002	Wasatch Plateau, located in Central Utah	0	UT	USA	SNOWMOBILE	2 seperate close calls in same area in 2 days
03-08-2002	Backside of Mount Judah, out of area @ Sugarbowl Resort	1	CA	USA	SNOWBOARD	1 skier and 2 snowboarders caught, 1 buried and killed
03-03-2002	Teton Pass	0	WY	USA	SKI	2 close calls on the same day
02-24-2002	Near Flat Top Mountain / Miner Basin in Northeast Mesa County	1	CO	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed

02-23-2002	Uinta Mountains, Currant Creek drainage, east of Heber	0	UT	USA	SNOWMOBILE	1 snowmobiler caught, buried, and injured
02-22-2002	HIGHWAY 2, West of Stevens Pass Ski Area	0	WA	USA	OTHER	1 automobile struck, carried, damaged, and partially buried
02-18-2002	American Fork Twins, backcountry terrain.	0	UT	USA	SKI	Close call...1 patroller caught, carried, partially buried, and injured.
02-16-2002	Mt. Abundance, north of Cooke City	2	MT	USA	SNOWMOBILE	3 snowmobilers caught, 2 buried and killed
02-10-2002	Jasper National Park	1	AB	CANADA	SNOWBOARD	1 snowboarder caught, buried, and killed wearing a transciever
02-10-2002	Mountians North of Whitefish Lake	1	MT	USA	SNOWMOBILE	1 snowmobiler, caught, buried, and killed wearing a transciever
02-10-2002	Mountains near Revelstoke, BC	2	BC	CANADA	SKI	4 skiers caught, 2 injured, 2 buried and killed
02-09-2002	Eureka Peak area near Williams Lake	1	BC	CANADA	SNOWMOBILE	2 snowmobilers caught, 1 snowmobiler buried and killed
02-06-2002	Near Crystal Peak	1	CO	USA	SKI	1 skier caught, buried, and killed wearing a transciever
02-01-2002	Just beyond the Aspen Highlands ski area boundary	1	CO	USA	SKI	1 skier caught, buried, and killed
01-31-2002	Lionhead, Near West Yellowstone	0	MT	USA	SNOWMOBILE	1 snowmobiler caught, buried, and rescued wearing a tranciever
01-31-2002	One drainage east of Stillman Creek, Uinta Mountains	1	UT	USA	SKI	1 skier, 1 dog caught, buried, and killed
01-28-2002	Mount Carlyle near Kaslo, 30 miles north of the Canadian border near Idaho.	3	BC	CANADA	SKI	Three backcountry skiers caught and killed
01-27-2002	Miller Creek outside of Cooke City	0	MT	USA	SNOWMOBILE	2 snowmobilers caught, 1 injured.
01-26-2002	Sheep Mountain, near Bonner, MT	4	MT	USA	SNOWMOBILE	5 snowmobilers caught, 4 buried and killed. ALL wearing transcievers.
01-26-2002	Arasta Creek, Gravelly Mountain Range	0	MT	USA	SNOWMOBILE	1 snowmobiler caught, buried, and rescued wearing a transciever
01-25-2002	Somewhere near Pemberton, BC	1	BC	CANADA	SKI	3 skiers caught and buried, 2 rescued, 1 killed
01-24-2002	Salt River Range, Bridger-Teton National Forest	0	WY	USA	SNOWMOBILE	2 snowmobilers caught, buried, and rescued
01-21-2002	Tunnel Creek, near Stevens Pass	0	WA	USA	SNOWBOARD	5 snowboarders caught, 1 with serious injuries.
01-21-2002	Skyline Ridge near Stevens Pass	0	WA	USA	SKI	Group of 5 skiers and boarders caught, 2 injured.
01-21-2002	Crater Lake National Park	0	OR	USA	SKI	6 people caught in 2 different avalanches, 2 people buried and rescued
01-14-2002	Brewer Creek area, Purcell Mountains; 44 km southwest of Invermere	1	BC	CANADA	OTHER	1 snowmobiler caught, buried, and killed...wearing a transciever
01-12-2002	Parker Ridge,near the Columbia Icefield	1	AB	CANADA	SKI	3 skiers caught, 2 fully buried, 2 rescued, 1 killed
01-12-2002	Cony Mt., dividing Gulkana Glacier and Cantwell Glacier, Delta Range	2	AK	USA	SNOWMOBILE	3 snowmobilers, caught, one partially buried and rescued, and 2 killed
12-31-2001	Thompson Lake, Flint Creek Range; 15 miles West of Deer Lodge	1	MT	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
12-24-2001	Mile 185 Parks Highway, southwest of Cantwell	1	AK	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed...wearing a transciever
12-23-2001	Swetmann Mine area of Chugach National Forest	1	AK	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed...wearing a transciever
12-11-2001	Point Whitshed, west of Cordova	1	AK	USA	SNOWMOBILE	2 Snowmobilers caught, 1 buried and killed

12-02-2001	Alpine Meadows Resort	0	CA	USA	OTHER	Close calls for mountain workers
11-30-2001	Black Lake region in Jewel Basin	0	MT	USA	SKI	1 skier caught, fully buried, rescued alive and uninjured!
11-28-2001	Rollins Pass near Boulder, Yankee Doodle Lake	1	CO	USA	SKI	2 backcountry skiers caught, 1 buried and killed
11-24-2001	Mt Rainier	0	WA	USA	SNOWBOARD	!!! Amazing recovery!!! 1 snowboarder caught, completely buried
11-14-2001	Tuckerman Ravine, Center Headwall	0	NH	USA	SKI	3 caught, carried, and injured
11-11-2001	Hatcher Pass, Alaska	1	AK	USA	SNOWSHOE	One snowshoer, caught, buried, and killed.
10-13-2001	Parkers Ridge, Near Jasper National Park	0	AB	CANADA	SKI	Solo Skier caught, partially buried, very lucky

2000-2001 US & CANADA, AVALANCHE FATALITIES & CLOSE CALLS

USA Fatalities:	**33**
Canada Fatalities:	**12**
Total Fatalities:	**45**

Date	Place	Fatalities	State	Country	Activity	Summary
04-28-2001	Storm Mountain - Stairs Gulch; Big Cottonwood Canyon	2	UT	USA	CLIMB	2 climbers caught, buried, and killed.
04-18-2001	Sun Bowl, Mt.Shasta	0	CA	USA	SKI	3 backcountry skiers caught, three partially buried
04-18-2001	Wild Horse Creek, near Cranbrook	1	BC	CANADA	SNOWMOBILE	5 snowmobiles caught, 1 killed, 1 injured
04-18-2001	Ram Falls near Nordegg, AB	1	AB	CANADA	SNOWMOBILE	1 snowmobiler caught buried and killed
04-11-2001	Easton Glacier, South side of Mount Baker	1	WA	USA	SNOWMOBILE	1 snomobiler caught, buried, and killed. Missing hiker recovered.
04-04-2001	South of Flathead Pass; Bridger Mtns.	1	MT	USA	SKI	1 skier caught, buried, and killed
04-04-2001	Near Sheep Mountain, Northwest of West Yellowstone	1	MT	USA	SNOWMOBILE	1 snowbiler caught, buried, and killed
04-04-2001	Truman Gulch West side of Bridger Range	0	MT	USA	SKI	2 skiers caught, carried, partially buried. 1 injured.
04-03-2001	Tenmile Range (West side), CO	1	CO	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
04-01-2001	Table Mountain southwest of Mt. Baker	0	WA	USA	SKI	1 skier caught, carried, completly buried, and rescued by own party
03-25-2001	Columbia Icefields	0	AB	CANADA	CLIMB	1 ice climber dies in fall after surviving an avalanche
03-24-2001	Seeley Canyon; Wasatch Plateau	0	UT	USA	SNOWMOBILE	Snowmobiler survives hour long burial
03-22-2001	Big White Mountain, near Kelowna	0	BC	CANADA	SNOWBOARD	5 snowboarders caught
03-22-2001	Renshaw mountain area near McBride	1	BC	CANADA	SNOWMOBILE	1 snowmobiler caught buried and killed
03-18-2001	Summit Lake, behind Courage Mountain	1	AK	USA	SNOWMOBILE	2 snowmobilers caught, carried, 1 buried and killed.
03-18-2001	Farwell Mountain in Routt County	1	CO	USA	SKI	1 skier caught, buried, and killed.
03-17-2001	Rogers Pass near the town of Golden	1	BC	CANADA	OTHER	4 skiers caught, one buried and killed
03-10-2001	Upper Chalk Creek, near Oakley	2	UT	USA	SNOWMOBILE	3 snowmobilers caught, 2 completely buried, and killed

03-05-2001	Prater Peak	1	WY	USA	SNOWMOBILE	2 snowmobilers caught, 1 buried and killed
03-05-2001	Crowsnest Pass, near Sparwood, BC	1	BC	CANADA	SNOWMOBILE	1 snowmobiler caught, carried, and killed.
03-01-2001	The Hogsback, near Eaglecrest Ski area	0	AK	USA	SKI	1 skier caught and buried, minor injuries
02-27-2001	Red Rocks Slide Path, near The Canyons	1	UT	USA	SKI	4 skiers caught, 2 completely buried, 1 killed
02-25-2001	Ohio Pass, CO near Crested Butte	1	CO	USA	SKI	1 skier caught, carried, and killed
02-24-2001	Bugaboos Mountains, near Invermere	1	BC	CANADA	SKI	2 skiers caught, 1 killed, 1 injured
02-24-2001	Absorka/Beartooth Range	0	MT	USA	SNOWMOBILE	Snomobiler Burial; Located by Transceiver
02-23-2001	Granite Canyon; Grand Teton National Park	1	WY	USA	SKI	1 skier caught, buried, and killed.
02-21-2001	Backcountry; Between Squaw and Alpine	2	CA	USA	SKI	2 skiers caught, buried, and killed
02-18-2001	Monsahee Mountains near Revelstoke	1	BC	CANADA	SKI	4 heli-skiers caught, 1 killed, 3 injured
02-17-2001	Mountains North of Cle Elum, WA	1	WA	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
02-13-2001	Thunder Meadows, Near Fernie Alpine Resort	2	BC	CANADA	SKI	13 skiers caught, 2 injured, 2 killed
02-07-2001	Brandywine Falls area, near Whistler	0	BC	CANADA	SNOWMOBILE	1 snowmobiler caught, back broken
02-06-2001	Rock Springs area, South of the Jackson	1	WY	USA	SKI	1 skier caught, buried, and killed
02-04-2001	Hyalite Drainage in the Gallatin Mountains	0	MT	USA	SNOWBOARD	1 snowboarder caught and buried in roadside terrain trap
02-03-2001	20 miles South of Eureka Lodge	2	AK	USA	SNOWMOBILE	3 snomobilers caught and buried, 2 killed, 1 escaped.
01-30-2001	Alpental Ski Area	0	WA	USA	SKI	One Professional Patroller caught, totally buried and rescued
01-29-2001	Twin Lakes, Chelan County	1	WA	USA	SNOWSHOE	2 snowshoers, 3 dogs caught, 1 person killed. 1 Dog killed.
01-27-2001	East of Mt. Shasta, Ash Creek Butte	0	CA	USA	SNOWMOBILE	1 snowmobiler caught, buried, and rescued by own group.
01-17-2001	Northwest of Jackson	1	MT	USA	SNOWMOBILE	1 snowmobiler caught,buried and killed
01-06-2001	Torpy Mountain near McGregor	1	BC	CANADA	SNOWMOBILE	1 snowmobiler caught buried and killed
01-01-2001	Aaron's Last Run, Turnagain Pass	0	AK	USA	SKI	1 Skier caught, carried, and buried. Rescued alive by own group.
12-31-2000	Emigrant Peak in the Absaroka Range	2	MT	USA	HIKE	4 hikers caught, 1 injured ,2 killed
12-29-2000	South Diamond Peak at Cameron Pass	1	CO	USA	SNOWBOARD	1 backcountry snowboarder caught, buried, and killed
12-29-2000	Pine Pass area, about 200 km north of Prince George	2	BC	CANADA	SNOWMOBILE	2 snowmobilers caught buried and killed
12-29-2000	Upper Middle Piney Creek	0	WY	USA	SNOWMOBILE	1 snowmobiler caught, buried, and rescued by own group
12-26-2000	CLOSED AREA; Discovery Basin Ski Area	0	MT	USA	SKI	3 skiers caught, carried, and 2 injured.
12-26-2000	Daisy Pass; north of Cooke City	0	MT	USA	SNOWMOBILE	1 snowmobiler caught, buried, and rescued by own group.
12-25-2000	Lionhead area near West Yellowstone	0	MT	USA	SNOWMOBILE	1 snowmobiler caught buried and rescued
12-25-2000	South Badger Creek, Jedediah Smith Wilderness	1	WY	USA	SKI	One skier caught, buried, and killed

12-19-2000	AREA NOT OPENED...Fernie Alpine Resort	0	BC	CANADA	SKI	1 skier caught, buried, and located alive by an avalanche rescue dog
12-17-2000	Marias Pass near Kalispell	2	MT	USA	SNOWMOBILE	2 snowmobilers killed
12-16-2000	Flagstaff Mtn.,North of Alta	0	UT	USA	OTHER	2 sledders caught, one partially buried, one buried and saved
12-14-2000	Snowbasin	0	UT	USA	OTHER	Plane crash in avalanche terrain, pilot killed in crash
12-14-2000	Willard Peak	1	UT	USA	SNOWMOBILE	1 snowmobiler caught buried and killed
12-10-2000	Teton Pass	1	WY	USA	SKI	1 backcountry skier caught, buried, and killed
12-09-2000	South of Cantwell, off Parks Hwy	1	AK	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed.
12-01-2000	Glory Bowl	1	WY	USA	SNOWBOARD	1 snowboarder caught buried and killed
11-27-2000	Sunlight Basin, near Cody	1	WY	USA	HIKE	1 hunter caught buried and killed
11-11-2000	Flat Top Mountain, North Gully, Chugach State Park	0	AK	USA	CLIMB	1 Climber critically injured and 1 dog slightly injured
11-04-2000	Red Mountain, near Red Mt. Pass	0	CO	USA	SKI	Group of 3 caught, 2 partially buried, 1 fully buried
10-30-2000	Red Cone bowl near Mammoth Lakes	0	CA	USA	SKI	2 skiers caught and injured

1999-2000 US & CANADA, AVALANCHE FATALITIES & CLOSE CALLS

USA Fatalities: **22**

Canada Fatalities: **10**

Total Fatalities: 32

Date	Place	Fatalities	State	Country	Activity	Summary
04-30-2000	Mt Baker	0	WA	USA	OTHER	1 hungry pooch
04-08-2000	Summit Lake, north of Paxson	1	AK	USA	SNOWMOBILE	1 snowmobiler caught buried and killed
04-08-2000	Snow Shoe Peak, near Talkeetna	1	AK	USA	SKI	2 backcountry skiers caught, 1 injured, 1 killed
03-31-2000	Copper Mountain, near Holden	0	WA	USA	CLIMB	2 climbers caught, one seriously injured
03-26-2000	Powder Mountain, near Whistler	1	BC	CANADA	SNOWBOARD	2 snowboarders caught, 1 buried and killed
03-22-2000	Gildart Peak, Swan Range in NW Montana	1	MT	USA	SNOWMOBILE	1 snowmobiler caught, not buried and killed
03-19-2000	Selkirk Mountains west of Bonners Ferry	1	ID	USA	SNOWMOBILE	1 snowmobiler caught buried and killed
03-19-2000	Wasp Creek near Pemberton	1	BC	CANADA	SKI	1 Heli-ski guide caught buried and killed
03-18-2000	Maroon Creek, near Aspen	2	CO	USA	SKI	3 Skiers caught, 2 buried, and killed
03-18-2000	Mt Albert on the Gaspe peninsula	1	QB	CANADA	SKI	1 skier caught buried and killed
03-16-2000	Frazier Lake	0	MT	USA	SNOWBOARD	1 snowboarder caught and injured
03-13-2000	Mt.Vallieres-de-Saint-Real, on the Gasp Peninsula	1	QB	CANADA	SKI	2 skiers caught, 1 minor inuries, 1 killed

03-05-2000	Mt. Cheam near Chiliwack	1	BC	CANADA	SKI	1 ski mountaineer caught by a cornice collapse
02-26-2000	Round Valley, near Bear Valley	0	CA	USA	SKI	A couple of close calls
02-25-2000	Snowbasin	0	UT	USA	SKI	5 skiers caught, 2 fully buried, 3 partial, minor injuries
02-23-2000	Blair Mtn. NW of Glenwood Springs	0	CO	USA	SNOWMOBILE	1 snowmobiler caught, buried. Revived by friends
02-23-2000	Mamquam River Valley	0	BC	CANADA	SNOWMOBILE	3 snowmobilers caught, 1 buried
02-20-2000	Mount Washington; Gulf of Slides Area	1	NH	USA	SKI	2 skiers caught, 1 buried and killed
02-19-2000	St. Charles Canyon, near Bear Lake	1	ID	USA	SNOWMOBILE	2 snowmobilers caught, 1 buried and killed
02-19-2000	Wright Peak, in the Adirondack High Peaks	1	NY	USA	SKI	6 skiers caught, 5 injured, 1 buried and killed
02-14-2000	Château-Richer, 30 km east of Quebec City	1	QB	CANADA	HIKE	2 teens caught and buried, 1 killed, 1 critically injured
02-02-2000	Government Meadows	0	WA	USA	SNOWMOBILE	2 snowmobilers caught, buried, very lucky
02-01-2000	Seward Highway, South of Anchorage	1	AK	USA	OTHER	3 bulldozer operators clearing road caught, 1 killed
01-30-2000	Diamond Peak, Lassen Volcanic NP	0	CA	USA	SKI	1 skier caught, buried 6 hours
01-28-2000	Smokey Mountains, near Sun Valley	0	ID	USA	SKI	1 skier caught, totally buried, recovered with beacon
01-26-2000	Cordova	1	AK	USA	OTHER	3 houses destroyed, 3 persons hit, 1 killed
01-25-2000	near Arapahoe Basin	1	CO	USA	SNOWBOARD	Backcountry snowboarder caught buried and killed
01-25-2000	Hurricane Gulch, near Aspen	1	CO	USA	SKI	1 backcountry skier caught buried and killed
01-23-2000	Jones Pass, West of Empire	1	CO	USA	SNOWSHOE	3 snowshoers caught and buried,1 killed
01-22-2000	Clark Lake, near Lionhead Peak	0	ID	USA	SNOWMOBILE	1 snowmobiler caught, buried and severely injured
01-19-2000	Near Mt Baker	0	WA	USA	SNOWBOARD	1 snowboarder caught, long ride, severly injured
01-17-2000	Tent Ridge, near Canmore	1	AB	CANADA	SKI	1 skier caught buried and killed
01-16-2000	Near Crystal Mountain	0	WA	USA	SKI	1 skier caught, long ride, broken leg
01-16-2000	Crystal Mountain Ski Area	1	WA	USA	SKI	2 skiers in closed area, 1 caught buried and killed
01-11-2000	Square Top Mtn. Summit County, Utah	2	UT	USA	SKI	2 alpine lift skiers, out-of-bounds, caught, buried, and killed
12-26-1999	Hatcher Pass, in the Talkeetna Mountains,50 miles north of Anchorage	1	AK	USA	SNOWMOBILE	1 snowmobiler caught, buried, and killed
12-26-1999	Hospital Creek, near Golden	1	BC	CANADA	SNOWMOBILE	1 snowmobiler caught buried and killed
12-21-1999	Quandary Peak	1	CO	USA	SKI	1 Skier caught, partially buried, and killed.
12-18-1999	mountains west of Eldora, CO	1	CO	USA	HIKE	Missing hiker suspected to be caught in avalanche.

12-17-1999	Cascade Waterall in Banff	1	AB	CANADA	CLIMB	5 climbers caught, 4 injured, 1 killed
12-14-1999	near Cameron Pass	1	CO	USA	SKI	1 skier caught, buried, and killed
12-07-1999	Rogers Pass	1	BC	CANADA	SKI	5 skiers caught, 4 injured, 1 dead
11-26-1999	Lone Mountain	1	MT	USA	SKI	2 skiers caught, 1 buried and killed

1998-99 US & CANADA, AVALANCHE FATALITIES & CLOSE CALLS

USA Fatalities: **29**

Canada Fatalities: **16**

Total Fatalities: 48

Date	Place	Fatalities	State	Country	Activity	Summary
05-14-1999	Blue Lake area near Sitka	1	AK	USA	OTHER	2 hikers caught, 1 killed
04-30-1999	University Range in Wrangell-St. Elias National Park, Ultima Thule Peak	1	AK	USA	OTHER	3 climbers caught, 1 buried, and killed
04-27-1999	Mount McGinnis, near Juneau	1	AK	USA	SNOWBOARD	1 snowboarder, caught, buried, and killed
04-16-1999	Talkeetna Mountains near Cantwell	1	AK	USA	SNOWMOBILE	7 snowmobilers caught, 3 injured, 1 dead, 6 machines damaged
04-15-1999	Cordova	1	AK	USA	OTHER	Construction worker caught, buried and killed
04-07-1999	Near Ophir in SW Colorado	1	CO	USA	SKI	1 skier caught, buried, and killed
04-03-1999	Chugach Mtns.; South of Eureka, AK	1	AK	USA	SNOWMOBILE	2 snowmobilers caught, 1 buried, and killed.
04-02-1999	Wood Camp Hollow, Logan Canyon	0	UT	USA	SKI	1 skier caught
03-21-1999	Sping Canyon, near Coalville	0	UT	USA	SNOWMOBILE	1 snowmobiler caught, leg broken
03-21-1999	Powerline Pass in Chugach State Park	0	AK	USA	SNOWMOBILE	3 snowmobilers caught, 2 buried
03-21-1999	TURNAGAIN PASS, Alaska	6	AK	USA	SNOWMOBILE	10 snowmobilers caught, 6 buried, and killed, 3 injured
03-15-1999	Rainbow Mountain, near Whistler	0	BC	CANADA	SKI	1 heli-ski guide caught, buried, and injured
03-12-1999	Alyeska Ski Resort	0	AK	USA	SKI	2 skiers caught and partially buried in large slide
03-06-1999	Arasta Creek, in the Gravelly Range	0	MT	USA	SNOWMOBILE	2 snowmobilers caught, 1 buried, blue, and very lucky
02-27-1999	Kokanee Provincial Park	0	BC	CANADA	SKI	3 backcountry skiers caught, and injured
02-20-1999	Portneuf Range Caribou National Forest	0	ID	USA	SKI	1 skier caught and injured
02-14-1999	Near Mt. Baker	2	WA	USA	SNOWBOARD	1 snowboarder dead; 1 skier caught,buried-still missing and presumed dead
02-10-1999	Hailey	0	ID	USA	OTHER	Park damaged, deer herd killed
02-09-1999	Town of Hailey	0	ID	USA	OTHER	3 houses damaged by avalanche
02-06-1999	Lone Peak Area, Little Cottonwood Canyon	1	UT	USA	SNOWSHOE	1 snowshoer caught, buried, and killed
02-06-1999	Cumberland Pass; 25 miles East of Crested Butte	3	CO	USA	SKI	4 caught, 1 partly buried, 3 buried and killed. (2 skiers, 1 snowmobiler)
02-06-1999	Lake Mary area, near the Tahoe-Donner summit	1	CA	USA	OTHER	3 caught, 1 buried and killed
01-30-1999	Grand Mesa	1	CO	USA	SNOWMOBILE	1 snowmobiler caught buried and killed

01-29-1999	East side of Mount Nebo	1	UT	USA	SNOWMOBILE	1 snowmobiler caught buried and killed
01-29-1999	Blue Mountains	1	OR	USA	SNOWBOARD	1 Snowboarder caught buried and killed
01-27-1999	Grouse Mountain, near Vancouver	1	BC	CANADA	OTHER	5 hikers caught, 4 injured, 1 missing and presumed dead
01-23-1999	MacAtee Basin, 10 miles S. of Big Sky	0	MT	USA	SNOWMOBILE	Snowmobiler Survives Avalanche in Southwest Montana
01-22-1999	Near the Aspen Highlands Ski Area	1	CO	USA	SKI	2 Out of bounds skiers, 1 caught buried and killed
01-19-1999	Casper Bowl, Jackson Hole	1	WY	USA	SNOWBOARD	1 snowboarder swept over 300' cliff and killed
01-18-1999	Near Mt. Baker	1	WA	USA	SNOWBOARD	Snowboarder caught, buried-still missing and presumed dead
01-14-1999	Near Lake Louise	1	AB	CANADA	SKI	2 skiers caught, 1 buried and killed
01-07-1999	Terrace, British Columbia Jan 7, 1999	2	BC	CANADA	OTHER	Two avalanche technicians, caught, buried, and killed
01-05-1999	Tri-County Peak, Park City	0	UT	USA	SKI	2 skiers caught and buried, 3 skiers fired and cited
01-04-1999	Togwotee Pass, WY > Dry Lake Creek Area	1	WY	USA	SNOWMOBILE	1 snowmobiler, caught, buried, and killed
01-02-1999	Southeast of Fairview, Utah	2	UT	USA	SNOWBOARD	2 snowboarders, caught and killed outside of Fairview, Utah
01-01-1999	Northern Quebec, Kangiqsualujjuaq village	9	QB	CANADA	OTHER	School gymnasium with 500 people inside, 9 killed, 25 injured
01-01-1999	Beaverhead Mountains above Rock Island Lake	0	MT	USA	SNOWMOBILE	2 snowmobilers caught, not buried, not injured. very lucky.
12-30-1998	Missoula Lake area, Bitterroot Mountains	1	MT	US	SNOWMOBILE	1 snowmobiler/shoveler caught, buried, and killed
12-24-1998	Cypress Mountain	1	BC	CANADA	SNOWBOARD	1 snowboarder caught, buried, and killed
11-15-1998	Lima Peaks area south of Dillon	1	MT	US	OTHER	1 Hunter caught, buried and killed
11-14-1998	Yoho National Park	1	BC	CANADA	OTHER	6 hikers caught, some injured, 1 fatality
11-13-1998	Kokanee Glacier Provincial Park	1	BC	CANADA	SKI	6 caught in 2 seperate avalanches, 1 missing and presumed drowned
11-07-1998	Mt. Baldy, Little Cottonwood Canyon	1	UT	US	SNOWBOARD	5 Snowboarders caught, 1 killed, 1 seriously injured

1997-98 US & CANADA, AVALANCHE FATALITIES & CLOSE CALLS

Total North American Avalanche Fatalities for the 1997-98 season: 46

* Indirectly related avalanche fatalities

Date	Place	Fatalities	Details
11-June	Mount Rainier, WA	1	12 climbers caught, 5 injured, 1 killed
31-May	Mount Hood, OR	1	4 climbers caught, 3 injured, 1 killed
17-May	Jasper, AB	1	1 snowboarder caught and buried and killed
26-April	Denali NP, AK	1	1 snowmobiler caught and buried and killed
23-April	Provo Canyon, UT		1 hiker caught twice, long rides, very lucky
22-April	Teton NP, WY		1 snowboarder caught, injured, buried
20-April	Watson Lake, Yukon	1	Teacher doing forest research caught and killed
20-April	Thompson Pass, AK	1	2 Heli-skiers caught, 1 killed

19-April	Berthoud Pass, CO	1	2 snowboarders injured, 1 died later from injuries
1-April	St. Marys Glacier,CO	1	2 climbers caught, 1 buried and killed
29-March	Silverton, CO		Cabin destroyed with man inside
26-March	Scotch Bonnett Peak, MT		1 snowmobiler caught and buried
8-March	Aspen, CO	1	1 out of bounds skier, caught, buried, and killed
7-March	Little Cottonwood Canyon, UT		7 cars, and 1 bus caught, 6 people injured, 1 seriously
7-March	High Eastern Artic, Canada	1	Unknown
1-March	Berthoud Pass, CO	1	2 caught,1 backcountry skier, 1 snowboarder buried and killed
26-Feb	Little Cottonwood Canyon, UT		2 cars, caught, 2 people injured
22-Feb	Mormon Hills, ID	1	1 snowmobiler caught, buried and killed
11-Feb	Donner Pass, CA	1	1 snowboarder caught, buried and killed
1-Feb	Barkerville, B.C.	1	1 snowmobiler caught, buried and killed
31-Jan	Grandview, AK		9 train coal cars caught, 3 coal cars derailed
29-Jan	Big Moutain, MT		1 skier caught and buried
25-Jan	Merritt, BC	1	1 skier caught, buried and killed
24-Jan	Inspiration Pass, MT	1	1 snowmobiler caught, buried and killed
21-Jan	Lizard Head Pass, CO	1	1 snowboarder caught, buried and killed
19-Jan	Cooke City, MT	3	3 snowmobilers caught, buried and killed
18-Jan	Blewett Pass, WA	1	1 snowmobiler caught, buried and killed
18-Jan	Sage Peak, MT	1	1 snowmobiler caught, buried and killed
18-Jan	Spring Canyon, UT	1	1 snowmobiler caught, buried and killed
17-Jan	Pleasant Creek, UT	1	1 snowmobiler caught, buried and killed
16-Jan	Elk Meadows, UT		8 Boy Scouts caught, 4 fully buried, 4 partly buried
15-Jan	Sun Valley, ID		1 skier caught and buried
12-Jan	Solitude, UT		1 skier caught, buried and injured
11-Jan	Encampment, WY	1	1 snowmobiler caught, buried and killed
11-Jan	Rock Creek, MT		1 snowmobiler caught, buried and very lucky
11-Jan	Little Cottonwood Canyon, UT	4*	1 skier caught, buried and injured, killed during evacuation in helicopter crash along with 3 air crew members
10-Jan	Norns Creek, BC	1	1 snowmobiler caught, buried and killed

3-Jan	Island Park, ID	1	1 snowmobiler presumed caught, buried and killed
3-Jan	Mission Mountains, MT	1	1 snowshoer caught, buried and killed
3-Jan	Shadow Lake, MT	1	3 or 4 snowmobilers caught, buried and 1 killed
3-Jan	Island Park, ID	1	1 snowmobiler caught, buried and killed
2-Jan	Kokanee Glacier, BC	6	6 skiers caught, buried and killed
2-Jan	New Denver, BC	2	2 skiers caught, buried and killed
2-Jan	Elliot Lake, BC	1	4 snowmobilers caught, buried and 1 killed
30-Dec	Guanella Pass, CO	1	1 snowshoer caught, buried and killed
29-Dec	Thompson Pass, AK		2 skiers caught, 1 fully and 1 partly buried
21-Dec	Hasler Flats, BC	1	3 snowmobilers caught, buried and 1 killed
29-Nov	Canmore, Alberta	4	4 hikers caught, buried and killed
24-Nov	Crow Pass, AK	1	1 hiker caught, buried and killed
22-Nov	Tony Grove, UT		2 snowboarders caught, 1 fully and 1 partly buried
9-Nov	Hatcher Pass, AK	1	2 snowboarders caught, 1 buried and killed

1996-97 US & CANADA, AVALANCHE FATALITIES & CLOSE CALLS

Total North American Avalanche Fatalities for the 1996-97 season: 35

Date	Place	Fatalities	Details
9-July	Mt Robson, BC	1	5 climbers caught, 1 buried and killed
5-July	Gladstone Peak, CO	1	2 climbers caught, 1 injured, 1 partly buried and killed
11-April	near Gakona Glacier , Alaska	1	1 snowmobiler buried killed
31-March	near Atlin BC	2	3 heliskiers caught and buried 2 killed
30-March	Lange Creek, near Golden, BC	1	1 snowmobiler buried killed
22-March	Selkirk Moutains, BC	2	2 heliskiers buried and killed
11-March	Castle Creek (Aspen), CO		1 snowboarder caught, buried and injured
9-March	Millville Peak near Logan, UT		3 skiers caught, 1 buried and injured, 1 Dog killed
9-March	Coquihalla Summit, BC	1	1 snowboarder buried and killed
8-March	Sundance Mtn near Priest Lake, ID	1	1 snowmobiler buried killed
3-March	Red Lodge Mountain, MT		1 out of bounds skier caught, injured, & buried
3-March	Yellowstone NP, WY	2	2 skiers buried and killed
21-Feb	Jackson, MT	1	1 snowmobiler killed

12-Feb	Cypress Bowl, BC	1	1 snowboarder caught, survived slide, killed by fall
2-Feb	Lange Creek, near Golden BC	1	1 snowmobiler buried and killed
1-Feb	Black Butte, MT		1 snowmobiler buried
1-Feb	West Mountain, near Casacade Idaho	1	1 snowmobiler buried and killed
25-Jan	Big Cottonwood Canyon, UT		1 snowshoer caught, buried 6' deep for more than 1.5 hours, no injuries!
25-Jan	Bridal Veil Falls, Provo Canyon, UT	1	1 ice climber killed, 1 injured
17-Jan	Resurrection Pass, AK	1	1 hiker buried and killed
13-Jan	Monashee Mtns., BC	2	3 heliskiers buried and injured, 2 killed
11-Jan	Logan, UT	3	3 skiers buried and killed
11-Jan	Little Cottonwood Canyon, UT		Numerous vehicles buried and smashed, some with occupants, several pedestrians buried. 4000 skiers spend the night.
11-Jan	near Montpelier, ID	1	1 snowmobiler buried and killed
29-Dec	St. Elmo, CO		2 snowshoers caught, 1 buried and injured
28-Dec	Mt. Index, WA	3	3 Climbers buried and killed
27-Dec	Jackson Hole, WY		1 car knocked off road, no injuries
26-Dec	Flagstaff Peak, UT	1	***Photos*** 1 snowboarder buried and killed
23-Dec	Chair Peak, WA	2	2 Climbers buried and killed
17-Dec	Spearhead Mtns, BC	3	3 heli-skiers buried and killed
12-Dec	Yoho NP, Alberta	1	1 skier buried and killed
7-Dec	Current Creek Peak, UT		1 snowmobiler buried, close call
7-Dec	Bountiful Peak, UT	1	***Photos*** 3 snowmobilers buried and 1 killed
6-Dec	Providence Lake, UT		1 snowmobiler buried, close call
11-Nov	Bridger Bowl, MT		1 skier caught, partially buried, and injured
9-Nov	Berthoud Pass, CO		1 snowboarder buried and injured (broken leg)

Summary of Alaskan Avalanches for 1996-97 Courtesy of the Alaskan Mountain Safety Center

1995-96 US AVALANCHE FATALITIES

Date	Place	Details
22-June	Mount Hunter, AK	2 climbers caught and killed
12-June	Mount St. Elias, AK	4 climbers caught and buried in their tent; 1 climber buried outside and killed
13-May	Mount Hunter, AK	2 climbers caught and killed
27-Mar	Maybird Gulch, UT	1 backcountry skier killed (slide for life)
24-Mar	Mt. Washington, NH	2 backcountry skiers (or hikers)buried and killed
9-Mar	W. Yellowstone, MT	1 snowmobiler buried and killed
4-Mar	East Vail Chutes, CO	1 out-of-bounds skier buried & killed
25-Feb	W. Yellowstone, MT	1 snowmobiler buried and killed
21-Feb	Vail, CO	1 resident buried and killed (roof avalanche)
18-Feb	Delta Range, AK	3 climbers buried and killed
11-Feb	Mission Mtns., MT	1 snowmobiler buried and killed
10-Feb	Sun Valley, ID	1 heli-ski guide buried and killed
10-Feb	Salt Mtn Range, WY	1 snowmobiler buried and killed
4-Feb	Arapaho Basin, CO	1 out-of-bounds snowboarder buried & killed
4-Feb	Taos, NM	1 backcountry skier buried and killed
3-Feb	Cottonwood Pass, CO	1 snowmobiler buried and killed
2-Feb	Solitude, UT	1 ski patroller buried and killed
27-Jan	Pyramid Pk, CO	1 climber buried and killed
23-Jan	Aspen, CO	1 backcountry skier buried and killed
21-Jan	Snowy Range, WY	1 backcountry skier buried and killed
14-Jan	Jackson Hole, WY	1 heli-skier buried and killed
5-Jan	Galena Pass, ID	2 snowboarders buried and killed
5-Jan	Mt. Washington, NH	1 hiker buried and killed
31-Dec	Vail Pass, CO	1 snowboarder buried and killed

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Photos

File Name	Size	Date Posted	Decription
looking down looking up lucky fellow scotts saw	58k 45k 68k 96k	2-26-04	Mike Baker was caught and partially buried on a snowmobile while climbing a small hill at Copper Creek, Lincoln, MT on 3/2/02. His friends dug him out.
Navajopk.jpg	85k	2-26-04	Avalanche on Navajo Peak, Chelan County, Washington where one snowmobiler was killed on 12/17/03. Avalanche started around the 6800 foot level and ended at about the 5400 foot level. Bill Quistorf Snohomish County Search and Rescue
avalanche.lg.18.2.9.mov	2.8meg (large)	10-1-03	KELLOGG, Idaho Snowmobilers Neal Houn and Greg Lanja out run a 20-foot wall of snow in full view of a friend's video camera.
lamongie1.jpg lamongie2.jpg lamongie3.jpg	44k 43K 54k	10-1-03	This is what happens when you build a chalet in the path of an avalanche. The chalet belonged to a local mayor who, quite sensibly, rented it to tourists. The Pyrenees had a very snowy winter which resulted in this chalet, plus several cars, being shunted down the mountainside by a slide at the start of February 2003. No-one was in the chalet at the time but two people in the car-park below were buried but rescued without much harm by the local piste patrol and mountain police. It is the second time a chalet has been hit at this location. David George
StAnton.jpg	53k	4-3-03	I was watching these 3 guys climbing to the top of the next valley to ski to Stuben, in the Austrian Alps. This resort is on the back side of St.Anton. The avalanche released 5-10 seconds before the photo was taken. Matt Jackson Norwich, England

Shames Start .jpg Shames Dep.jpg	43k 53K	4-3-03	Here are some photos of Path #2 which affects Shames Mountain Ski Area access road in Terrace, BC. The avalanche was initiated by helicopter control. It produced a size 3.5 avalanche that blocked the road. Steve Brushey
skiYuma2.jpg	114k	2-24-03	How a "Old" snowranger does avalanche control work. Photo of me skiing on control work - easy day not much action. Kenneth E. White, Vice-President Friends of the NW Weather & Avalanche Center
Avalanche.jpg AbbottOBSERVATORY.jpg howitzer.jpg HoarFROSTandRuler.jpg	70k 44k 82k 63k	1-21-03	Images from Joe Shortt Avalanche near Rogers Pass BC, Canada Abbott Observatory, Rogers Pass Canadian Artillery firing in Rogers Pass Hoar frost at Rogers Pass
avalanche-.jpg	37k	10-23-02	B+W controlled slide in Telluride Co. HUGE for more info or large prints email ealphoto@hotmail.com or visit www.blacklightphoto.com. Eric Limon Copyright
P1130006.JPG	94k	4-6-02	Photo from Park City Mountain, Utah. The crown was about 3 feet and flanks were about 5 feet. Photo by Ben Mackay
lavina.jpg	94k	1-24-01	Avalanche falling down through the North Face of Pik Lenina (7134 m above sea level). Altitude difference between Camp1 (4200 m, the photo was taken from there) and summit is about 3000 m. Photo by Jan Pala, Czech Republic
26avalanche.jpg	65k	12-26-00	Avalanche on Mt. St. Elias, St. Elias Range, AK 1997 . Photo by Paul Sharwell
aval_spas.jpg	66k	12-26-00	A nice slab that fell on one of the most popular ski runs in Vitosha Mountain, Bulgaria. Photo by Momchil Panayotov
dumpage.jpg	45k	4-17-00	Slide on the Seward Highway, AK about to hit tidewater. Photo by Terry Onslow
avalanche1.jpg avalanche2.jpg avalanche3.jpg avalanche4.jpg avalanche5.jpg	50k 53k 60k 119k 168k	3-Apr-00	Cornice control avalanche, Cariboo Mts. B.C.Photos by Brad White
Mvc-008f.jpg	50k	14-Mar-00	Large slide that killed a bulldozer operator 8 miles north of Girdwood, AK. The dark spot in the center is where the D-6 came to a rest. Photo by Kurt Troyer
121.jpg	50k	28-Feb-00	huge avalanche in Karakorams (May 1988)
rime_plus2.jpg	47k	11-Jan-00	Rime ice? What Rime ice?
Mvc-025f.jpg	29k	11-Jan-00	Jim Kennedy sends a shot towards Alyeska's Glacier Bowl cornice as Veatch and Descutner watch.
highmrk2.jpg	80k	30-April-99	High marking smowmobiler gets a surprise. Sequence of photos by Jeff Halligan, Snow Ranger, Payette National Forest
slide_1.jpg	50k	16-April-99	Artificially released avalanche by 160-mm mortar firing in Kirovsk, Murmansk region, Russia, 1998. The volume of slide is 30000 cubic meters. Photo by P.Chernouss
ruby2.jpg	36k	1-Feb-98	Large avalanche in Lamoille Canyon, Ruby Mountains. Photo By Joe Royer.
superior.jpg	70k	14-April-98	Slab avalanche sequence on Mount Superior, Utah, triggered by helicopter bombing. Photos by Dan Judd
RUBYWX2L.jpg	48k	23-Mar-97	Ruby Mountain Heli-Ski remote weather station, Photos by Joe Royer
elklong2.jpg	80k	26-Feb-97	Elk Point running big above Sundance UT, Photos by Dan Judd

slide.jpg	21k	2-Feb-97	Slide Canyon running to the highway in Provo Canyon, UT Photo by Jerry Hill
milford95.jpg	27k	22-Jan-97	Avalanche on the Milford Road, New Zealand, Photo by Peter Weir
ruby.jpg	20k	31-Dec-96	Avalanche in the Right Fork of Lamoille Creek, Ruby Mountains. Photo By Joe Royer
mbaldy2.jpg	21k	28-Sep-96	Nice slide off of the baldy shoulder at Alta, Utah about to hit the Center for Snow Science at Alta impact pylon. Photo by Piney
105mm.jpg	13k	24-Sep-96	Incredible photo of a 105mm recoiless rifle being fired. Photo by Mike Boissonneault.
argenta.jpg	17k	24-Sep-96	The Agrenta slide path in Big Cottonwood Canyon, Utah, after a major slide that cleared 50 years of growth out of the way. Photo by Dan Judd.
bridalveil1.jpg	20k	24-Sep-96	What is left of the Bridal Veil Falls lower terminal after it was hit by large powder avalanche. Located in Provo Canyon, Utah. Photo by Bruce Tremper.
bridalveil2.jpg	21k	24-Sep-96	Another photo of the Bridal Veil slide. Photo by Bruce Tremper.
porter.jpg	16k	24-Sep-96	A large destructive slide that cleared lots of timber in the Porter Fork drainage of Millcreek Canyon, Utah. Photo by Bruce Tremper.
emmas.jpg	17k	24-Sep-96	Photo of a car that was parked in the wrong place under the Emma 3 slide path at Alta, Utah. Photo by Dan Judd.
milford1.jpg	16k	24-Sep-96	Starting zone of the Sinks avalanche path above the Milford Road in New Zealand. Photo by Dan Judd, Courtesy of Wayne Carren & Peter Weir.
milford2.jpg	19k	24-Sep-96	Splatter zone of the Sinks path shown above. Rocks the size of basketballs are picked up and thrown from the river bed and hurled to the other side of the valley! Photo by Dan Judd, Courtesy of Wayne Carren & Peter Weir.
milford3.jpg	11k	24-Sep-96	Water pouring off the Gulliver's avalanche paths during a storm. Above the Milford Road, New Zealand. Photo by Dan Judd, Courtesy of Wayne Carren & Peter Weir.
milford4.jpg	13k	24-Sep-96	Large dust cloud from an avalanche above the Homer Tunnel on Milford Road, New Zealand. Photo Peter Weir.
roman.jpg	14k	24-Sep-96	Sobering photo of the slide in Wolverine Cirque, Big Cottonwood Canyon, Utah, that killed Roman Latta. Photo by Neil Ryland
wxman.jpg	20k	24-Sep-96	Your suspicions about weather forecasters are confirmed... Photographer unknown

An Introduction to

The ABC's of Plate Tectonics

by Donald L. Blanchard

Earth Sciences Home Page

Contents:

Introduction:

The Theory of Continental Drift has had a long and turbulent history since it was first proposed by Alfred Wegener in 1910. Vigorously challenged yet widely ignored, the theory languished for half a century, primarily due to its lack of a plausible mechanism to support the proposed drift. With the discovery of sea-floor spreading in the late 1950's and early 60's, the idea was reinvigorated, this time as the Theory of Plate Tectonics.

Plate tectonics is now almost universally accepted, its mechanisms plausible and to a degree demonstrable. However, many details of the mechanism are yet to be worked out, and many theories involving various details of plate tectonics rest on some questionable assumptions. This set of pages attempts to define some of the basic principles of the mechanism, and to examine their effect on the creation of landforms.

What follows is NOT a summary of the current thinking about plate tectonics and its mechanisms; rather, many new, and probably highly controversial, ideas are presented for consideration. What IS presented is a broad analysis of the basic principles that should apply to the movements of plates, some new hypotheses about how they apply to convection and landform formation, and some expected scenarios for differing tectonic events.

For those unfamiliar with the theory of plate tectonics, a separate page - The Basics of Plate Tectonics - is provided. This summary offers a brief condensation of the basic principles of Plate Tectonics. A much more comprehensive explanation of Plate Tectonics can be found on the USGS Web Site.

| Lesson #1: Buoyancy and Floating Continents |

This file last updated on December 1, 1999.

EARTHFORCE
in the crust

Go outside, find a flat piece of ground, and stand perfectly still. You won't be able to notice it, but the ground beneath your feet is moving. Imagine that you are balancing on a raft on a pond, gently drifting. If you live on the North American continent, the ground beneath you is one giant raft drifting westward very slowly, about 2.5 centimeters (one inch) per year. Get a ruler and think about that. Imagine that you move just one inch during an entire year. That seems pretty slow, but, considering the size of the continent, the force of that movement can be huge. If a bicycle moved an inch and bumped into you, it wouldn't really hurt. If a car moved an inch and bumped into you, it might make a bruise. If a school bus moved an inch, the bump might break a bone. If a tractor trailer bumped into you, you'd notice.

Scientists think that the entire crust of the Earth is broken into big pieces called plates. All of the plates are drifting on the liquid molten magma of the mantle beneath the crust. Even though they're drifting very slowly, when they bump into each other, the force is huge. People who live near the edges of a plate notice the bumping. Most often, the earth beneath them quakes and shakes as the plates bump and rub.

Scientists call this action plate tectonics. Over millions of years, plate tectonics has changed the appearance of the Earth's crust. Besides the crustal plates drifting and moving to different locations, the pushing and pulling between plates causes mountains and valleys to form. Scientists think that, long ago, the crustal plate of India collided with the huge crustal plate of Asia to form the Himalayas, the highest mountains in the world. While crustal rock is solid, it does have some elastic properties. With enough force and heat, rock can bend and change shape. When the two plates bumped into each other, rock along the edges pushed upward. Even today, scientists think that the Indian plate is still colliding with the Asian plate, moving about five centimeters (two inches) per year, and causing the highest mountains to rise even higher.

Most of the plates meet under the oceans where the force of their pushing and pulling may sometimes not even be noticed. Some plates, like the Indian and Asian plates, meet on dry land. The Himalayan mountains were formed when the two plates pushed together. The Pacific and North America plates also meet on dry land. These two giant crustal plates are not pushing together, however. They are scraping against each other. The Pacific plate is drifting Northward, scraping along the edge of the North American plate. The result of this tremendous force is the San Andreas fault, which cuts vertically through the state of California for nearly 1,125 kilometers (700 miles).

Scientists think that the San Andreas fault may be one hundred million years old. The crack in the crust between the plates is at least thirty-two kilometers (twenty miles) deep. For many years, scientists have used the fault to study the crustal plates, properties of rock, and the core of the Earth.

The San Andreas fault is a dangerous laboratory, however. In some places, the force of the plate scraping has broken roads, relocated streams, and lowered mountains. The biggest danger, of course, is from the quaking. The crustal plates are pushing and pulling causing motion. The mantle beneath the crust is pushing and pulling causing motion. All of that force builds up energy. When the energy gets released, the crust vibrates.

Each month, scientists observe several small earthquakes along the San Andreas fault. Most of them are barely noticeable. Once in a while, however, the energy really builds and releases a tremendous vibration.

Earthquakes are a natural part of the Earth's geology and are not necessarily dangerous. In the past 150 years, a tiny blip in the lifespan of the fault, Americans have moved to California and built structures near the fault. During that time, many lives have been lost due to quakes along the fault. In 1906, for example, the crust vibrated strongly for forty-five seconds. In the history of the fault, the 1906 quake was minor. However, in nearby San Francisco, a young city was destroyed. Five hundred people died—not from the quake, but from the falling buildings and raging fires that resulted. Buildings tumbled to the ground, breaking streets below. Woodstoves and oil lamps ignited the rubble. The city burned for three days.

In spite of the destruction and potential for future earthquakes, the citizens of San Francisco stayed and rebuilt their city. Today, buildings are "earthquake- resistant." Emergency procedures are ready and waiting. Yet, in 1989, another quake rocked San Francisco, killing sixty- two people, destroying buildings, and igniting fires across the city. Clearly, there is no way to be prepared completely for violent vibrations in the crust.

Learn where the earth quakes most often so that you know the greatest danger zones. Everyday, the **EARTHFORCE** is quaking somewhere. Browse these websites daily to see where.

Current Quakings

- Today's Earthquake Activity Around the World
- Recent Earthquake Events
- Up-to-the-Minute Southern California Earthquake Map
- Maps and Lists of Current Earthquake Activity
- Earthquake and Seismicity Maps

Explore **EARTHFORCE** and earthquakes by browsing these selected websites.

Plate Tectonics

- Earth's Interior
- This Dynamic Earth: The Story of Plate Tectonics
- The ABC's of Plate Tectonics
- The Formation of Pangaea: The Making of a Supercontinent
- Plate Tectonics: The Cause of Earthquakes

Earthquake Science

- Earthquake FAQ
- Earthquake Fact and Follies
- What's Shakin'?
- Earthquake ABC: A Child's View of Earthquake Facts and Feelings
- What is Richter Magnitude?
- Seismic Deformation
- Every Place Has Its Faults
- Earthquake Quiz

Teacher Lessons

- Big Trouble in Earthquake Country
- Earthquakes: Musical Plates

Interactives

- Virtual Earthquake
- Java Earthquake Globe
- Java Earthquake Elastic Rebound Animation

History

- Earthquakes by Twain, London, Darwin, and Muir
- A Brief History of Seismology to 1910
- San Francisco Earthquake 1906
- The Quakeline Database
- Earthquake Engineering Slide Information System

Preparedness

- Putting Down Roots in Earthquake Country
- The EQE Earthquake Home Preparedness Guide

skip navigational links

USGS
science for a changing world

Earthquake Hazards Program – Northern California

Latest Quake Info	General Quake Info	Hazards & Preparedness	Earthquake Research	Special Features	Additional Resources	Search

You are here: Quake Home

Other USGS Earthquake Websites   Go!

62%

Earthquake Probabilities for the San Francisco Bay Area
USGS and other scientists conclude that there is a 62% probability of at least one magnitude 6.7 or greater quake, capable of causing widespread damage, striking the San Francisco Bay region before 2032.

Real Time Earthquake Maps
- California-Nevada (with fault names)
- USA
- World

Real-time Shaking Maps
For California earthquakes of Magnitude 3.5 and larger

Earthquake news and highlights:

Magnitude 3.8 WYOMING August 29, 2004 Magnitude 4.3 GREECE August 24, 2004 Magnitude 3.5 ALABAMA August 19, 2004 07/26/04 - Silent Earthquake Under Western Washington - Update Magnitude 7.3 SOUTHERN SUMATRA, INDONESIA July 25, 2004 Magnitude 4.9 - OFFSHORE OREGON 2004 July 12 16:45:00 UTC Magnitude 5.2 EASTERN TURKEY July 01, 2004 07/01/04 - Earthquake Activity Near Lakeview, OR 05/03/04 - Keilis-Borok California Earthquake Prediction

Latest Quake Info
Real-time maps of recent earthquake activity in California, the nation and the world; real-time seismograms; regional earthquake activity reports; recent significant earthquakes.

General Quake Info
Earthquake basics and educational material; geological and historical information; links to professional and amateur organizations; online access to earthquake data.

Hazards & Preparedness
How to prepare your home, business and

1906 Earthquake Centennial Alliance
The centennial of the 1906 San Francisco earthquake will mark a century of progress in understanding earthquake hazards and reducing risks. The Alliance plans to highlight scientific achievements and commemorate the cultural and social response to this historic event. Learn more about The Great 1906 San Francisco earthquake.

Frequently Asked Questions
Have a question? We probably have the answer.

family for earthquake hazards; earthquake probabilities; shaking hazard maps; liquefaction hazard and earthquake engineering.

Earthquake Research
Current research activities and results in seismology, crustal structure and deformation, geology and borehole physics.

Special Features
Earthquakes in the news, special events and research developments of particular or topical interest.

Additional Resources
Links to other earthquake websites; "Ask-a-Geologist;" publication lists and bibliographies; ordering USGS products.

Search Quake Site:

Search

Advanced Search

U.S. Geological Survey, Earthquake Hazards Program
URL http://quake.wr.usgs.gov/
Contact:webmaster@ehznorth.wr.usgs.gov
Last modification: April 21, 2003

Earthquakes

[» Shake With The Quake Story]
[» Rumble Tumble Story]
[» The Northridge Earthquake]
[» Fact or Fiction?]
[» Home Hazards Hunt]
[» Pacific Hurricane Names]
[» Historic Earthquakes]
[» Tasty Quake]
[» Map of Earthquake Risk States]
[» Earthquake Disaster Math]
[» Disaster Intensity Scales]
[» Water, Wind and Earth Game]
[» Earthquake Legends]
[» Jess & Sam's Earthquake]

Earthquakes are the shaking, rolling or sudden shock of the earth’s surface. Earthquakes happen along "fault lines" in the earth’s crust. Earthquakes can be felt over large areas although they usually last less than one minute. Earthquakes cannot be predicted -- although scientists are working on it!

Most of the time, you will notice an earthquake by the gentle shaking of the ground. You may notice hanging plants swaying or objects wobbling on shelves. Sometimes you may hear a low rumbling noise or feel a sharp jolt. A survivor of the 1906 earthquake in San Francisco said the sensation was like riding a bicycle down a long flight of stairs.

The intensity of an earthquake can be measured. One measurement is called the Richter scale. Earthquakes below 4.0 on the Richter scale usually do not cause damage, and earthquakes below 2.0 usually can’t be felt. Earthquakes over 5.0 on the scale can cause damage. A magnitude 6.0 earthquake is considered strong and a magnitude 7.0 is a major earthquake. The Northridge Earthquake, which hit Southern California in 1994, was magnitude 6.7.

Earthquakes are sometimes called temblors, quakes, shakers or seismic activity. The most important thing to remember during an earthquake is to DROP, COVER and HOLD ON. So remember to DROP to the floor and get under something for COVER and HOLD ON during the shaking.

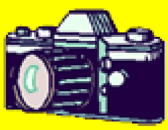

Julia and Robbie The Disaster Twins


Things to Know


Turtle Tale


Pets and Disasters


How to Protect Your Home from Disasters


Photos


Canine Heroes

FEMA for Kids

Federal Emergency Management Agency

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You requested a page that is not available on our site. Our content is constantly updated, so it's possible that the page you requested has been removed or has changed location.

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- **Homework** - Use our tips and tools to help you get your homework done faster
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- **Graduate School** - Find the right degree path and get grad-level test tips
- **eLearning** - Enroll in online classes and degree programs
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Produced by
Dr. M. Mustoe, Area Coordinator for Geography at the
University of Texas of the Permian Basin
Odessa, Texas

If you've recently been in an earthquake and have observed your pets or animals doing strange things, please check the
Seismic Activity and Animal Behaviour SAAB site.

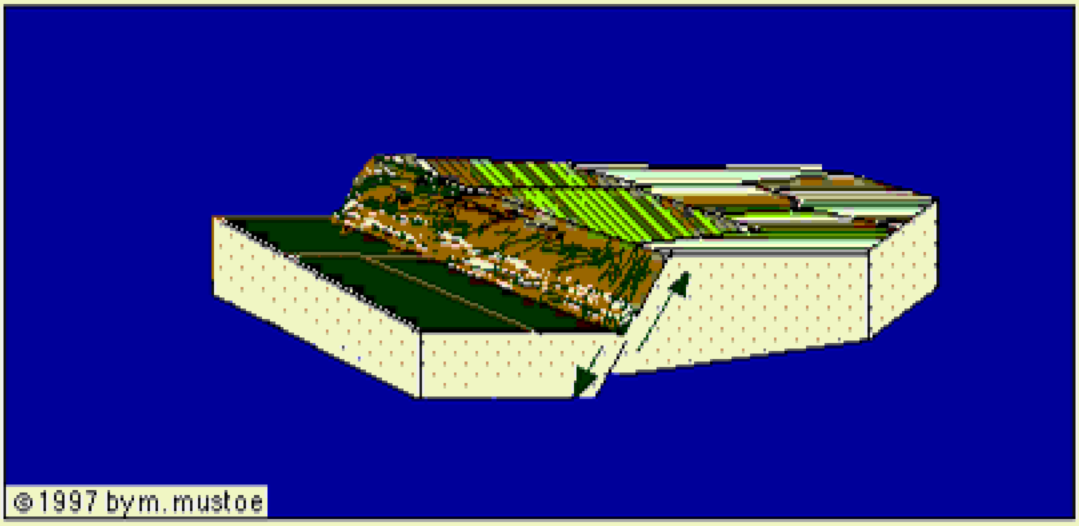
Also see Dr. M's other sites: Glaciers, Columbia Plateau Basalt, Ribbon Cliff Earthquake Granite
Home, Omak, Washington, Amateur Radio Operator KA 7 GQB

Designed With

Object DANCER™ Made With A Mac

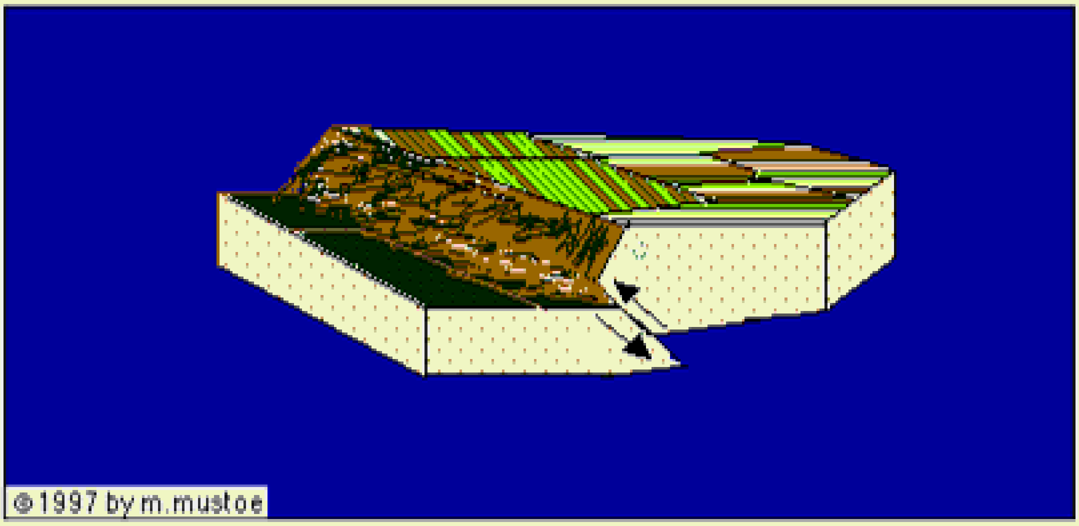
The Four BASIC Types Of Faults

(This does not include growth faults)



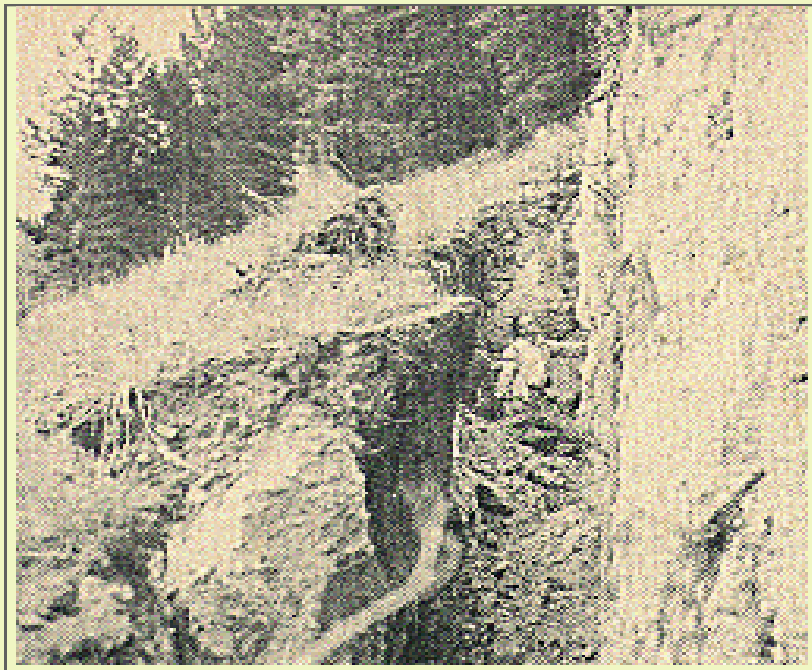
The Normal Fault

The normal fault is not necessarily normal in the sense that it is common....because.... it is not the most common of faults. However what is normal about them is that their movement tends to follow the gravitational pull on the fault blocks involved. The fault plane on the normal fault is generally very steep. In a normal fault the two involved blocks are (by gravity) pulling away from one another causing one of the fault blocks to slip upward and the other downward with respect to the fault plane (it is hard to determine whether both or just one block has moved.). The exposed upward block forms a cliff-like feature known as a fault scarp. A scarp may range from a few to hundreds of meters in height and their length may continue for 300 or more kilometers (around 200 miles).



The Reverse Fault

The reverse fault is a normal fault except the general movement of the fault blocks is toward each other, not away from each other as in the normal fault. This forms a thrust fault type expression on the surface with material overlaying other material.



USGS Photo

The night of 17 August marks the aniversary of a little talked about yet profoundly significant earthquake known as the Hebgen Lake, or Montana-Yellowstone Eartquake. The event took place in 1959 in a remote...but well visited region around West Yellowstone, Montana. On that night nearly 18,000 campers and park personnel, felt a shock that had originated ten miles below the suface in the vicinity of the Madison River Canyon. As a result of that intensity 7.1 earthquake, 43 million cubic yards of rock slid as a block into the Madison Canyon daming up the Madison River, below Hebgen Dam. The lake basin behind Hebgen dam tilted with the south side rising and the north side dropping. This caused a seische...a lake tsunami...that crested the dam four times and kept the lake in motion for nearly 11 hours. At Yellowstone Park, hot springs and geysers, that had never been known to erupt before erupted. The shock wave was felt in an area of 500,000 sqaure miles. It caused wells to fluxuate in Texas and and as far away as Hawaii and Puerto Rico. Nine people lost their lives and 19 were listed as missing in this event. The image above shows a fault scarp where the block was thrown down at one end of the valley. Displacement here was about 20 feet and ran hundreds of feet long.

New fault scarps along Hebgen Lake, Montana. About 20 feet displacement. This area covered the main road. U.S.F.S. Photo

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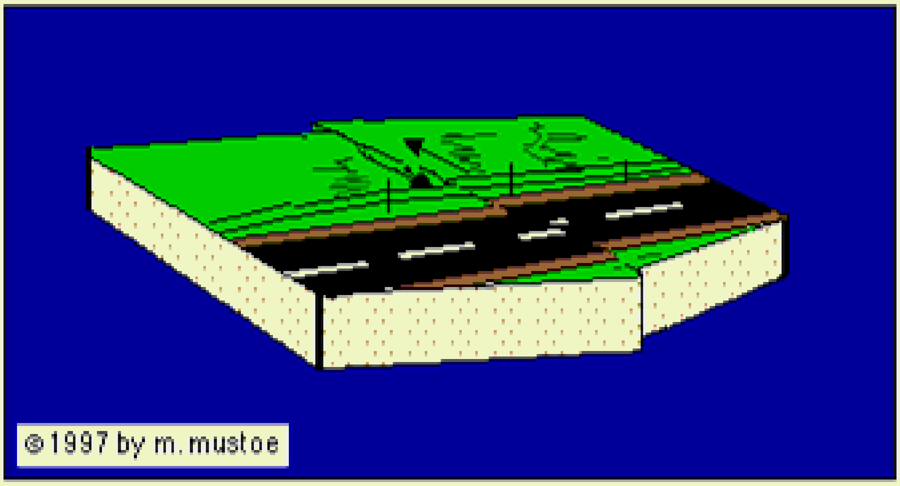
The Initial Stages Of Landforms

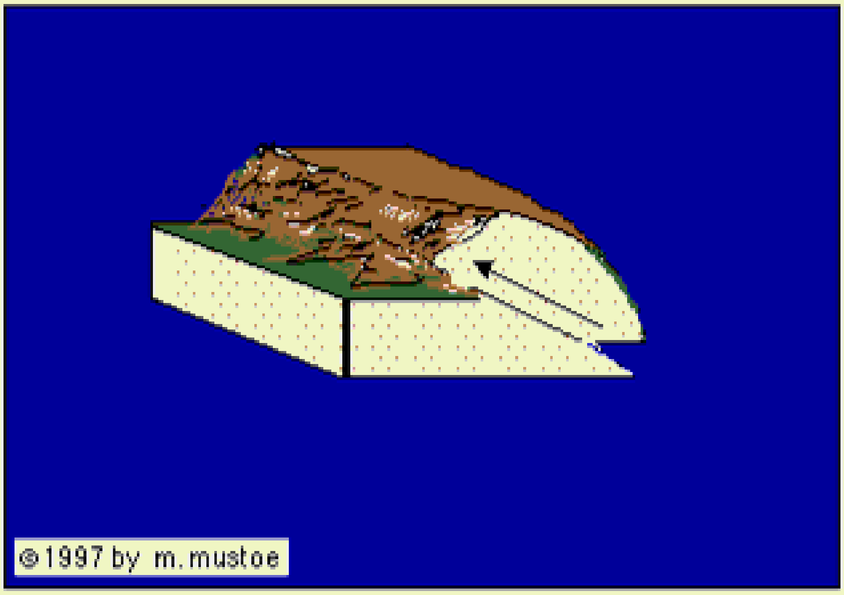
The phrase "initial stage" means the beginning stages of a landform. Click here for a look at a graben and horst system.

Two More Fault Types



Transcurrent Fault (Strike-Slip Fault)

Probably the most well known and well studied fault is the transcurrent (strike-slip) fault known as the San Andreas fault of California. This fault marks the margin line between the Pacific and North American Plates. Movement on a strike strip fault is generally horizontal. On the surface, scarps form as hills crossing the fault zone are torn apart by movement over time. Actually anything crossing this fault zone is either slowly torn apart, or offset. Rivers crossing the fault line are called offset streams and are classic signatures of fault activity along the San Andreas. These faults can be very long, the San Andreas is nearly 600 miles long.



Thrust Fault

In the 1994 Northridge, California event, a deep thrust fault located about 18 km under the city of Los Angeles produced an eartquake that registered a magnitude of 6.7. When thrust faults are exposed on the surface overburnden material lies over the main block. They are normally associated with areas of folded surfaces and or mountaineous regions. The dip angles of thrust faults are normally not as steep as a normal fault. Chief Mountain, in Montana (one of the places we look at using the USGS quads in the principles of geography class) is an example of a thrust mountain.

---

e-mail the teacher click the seismogram

Just For Fun: The "grapevine hill" which disects the San Andreas Fault on Interstate 5 in Southern California is mentioned in what popular song? Better yet...who did the original version......here's a hint:
"My daddy said, son your're gonna drive me to drinkin' if you don't stop driving that ...."

Of Interest To My Geography Students

Internet Links To Earthquake Data and Information

New Information on the 01/02/28 Event
Idaho Geologic Survey

Oklahoma Geological Survey
Seismo-Surfing the Internet

North Idaho Seismic Network

University of Utah Intermountain West Earthquakes

Lewis and Clark Zone

Various Northwest Sites Boise State

[NE of Olympia (Nisqually Earthquake) , 01/02/28 18:54:31 UTC 47.17N 122.73W Depth: 49.0 km 6.8M]

[Pacific Northwest Earthquakes USGS]

[1949 Seattle, 04 13 19:55:42 UTC, 6.9, MM VIII]

[1965, Puget Sound 04/29/1965 04 29 15:28:43.7 UTC, 6.5, VIII]

(Felt all the way to B.C. and Montana, Dr M was in grade 5 during this one and still remembers it shaking the room)

[University of Washington Geophysics]

[Pacific Northwest Earthquake Information (PN Seismograph Network)]

[Earthquakes for Kids and Grownups! USGS]

[Earthquake Hazards Program]

[The Southern California Earthquake Center]

[Earthquake information from the USGS]

[Recent Earthquake Data on the Net]

[Alaska earthquake Center]

[The Great Alaska Earthquake of 1964] **(Attn. Kodiak Quiverings Assignment students)**

[UC Berkley Seismographic Station Home Page]

[About the Northridge Earthquake]

[Geologic Hazards Team]

[Earthquake Eyewitness Accounts (CNN)]

[Chronological Earthquake Index]

[Air Talk: Earthquakes and Structral Design]

[Northridge Earthquake Animations]

[Emergency Service Action]

[Northridge Slideshow Page]

[The Global Earthquake Response Center]

[UCD Active Tectonics]

[Responses to Radio Stations During the Loma Prieta Event]

[Collapse of Freeway in the Loma Prieta Event]

[Loma Prieta Earthquake]

[San Andreas Fault]

[Earthquake Warning System]

[Make Your Own Seismogram]

[Mono Lake Activity]

A Model of Three Faults

*This packet is only available online.

Background

One of the most frightening and destructive phenomena of nature is a severe earthquake and its terrible aftereffects. An earthquake is a sudden movement of the Earth, caused by the abrupt release of strain that has accumulated over a long time. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface slowly move over, under and past each other. Sometimes the movement is gradual. At other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free. If the earthquake occurs in a populated area, it may cause many deaths and injuries and extensive property damage.

Today we are challenging the assumption that earthquakes must present an uncontrollable and unforecastable hazard to life and property. Scientists have begun to estimate the locations and likelihoods of future damaging earthquakes. Sites of greatest hazard are being identified, and designing structures that will withstand the effects of earthquakes.

Back to top

Materials and Instructions

Objective

Students will observe fault movements on a model of the earth's surface.

Time Needed

1 or 2 Class periods

Materials Needed

- Physiographic map of the world
- Per group
- Crayons or colored pencils
- Scissors
- Tape or glue
- Metric ruler
- Construction paper

THE LEARNING WEB

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Search Wizard

with more search options.

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To Order USGS Teaching Packets,
1-888-ASK-USGS
ask@usgs.gov

Fun Stuff

Playtime Wizard

Image Wizard

Map Wizard

E-Cards

Wallpapers

- Fault Model Sheet (included)

Instructions

1. Have students work in pairs or small groups.
2. Display the fault models in the classroom after the activity.
3. An excellent world physiographic map showing the ocean floor, can be obtained from the National Geographic Society.

Back to top

Background | Materials and Instructions | Application Phase | Extension | Part 1 | Part 2 | Part 3 | Model

Explore These...
Earth Hazards
Water
Plants & Animals
Maps & Images
Rocks & Images
Real-time Info
Ecosystems
Natural Resources

All USGS teaching packets are based on National Education Standards.

Home | **Site Map** | **Contact Us** | **Education** | **USGS Home** | **Ask USGS**

The Great 1906 Earthquake And Fire

The San Francisco 1906 Earthquake Great Register

In response to repeated requests through our website we are setting out to compile a new and more accurate account of those affected by the 1906 earthquake. We want information on everyone who was here at the time, both survivors and those who perished. Click on the 1906 Earthquake Great Register to find out how to submit your information.

April 18-23 Earthquake Timeline

The Mayor's "Shoot-to-Kill" Order — April 18th

Earthquake Newspaper Clippings

Eyewitness Accounts

"Who Perished"; List of Dead from the 1906 Earthquake

San Francisco Fire Department Report

Police Department Report

U.S. Army Operations During the Earthquake and Fire

U.S. Navy Operations During the Earthquake and Fire

Engineering and Scientific Reports

Southern Pacific Railway Company

Relief and Recovery Efforts

Photographs of the 1906 Disaster

Gladys Hansen's Earthquake Almanac 1769 - 1994

Purchase Gladys Hansen's Denial of Disaster signed by Gladys

Events: Departmental - Geography - Geology - Anthropology

DEPARTMENTAL EVENTS

Upcoming Events and Field Trips

Thursday October 9, 2003 - Mausel Open - Terre Haute, IN
Dust off your clubs and put on a party hat, it's time for the Mausel Open!
Golf Event --- Mark's Par Three @3pm
Cookout --- The Mausel's @ 5:30pm

October 12-18, 2003 - National Earth Science Week - Terre Haute, IN
The Earth Science Club will be hosting several events for Earth Science Week.

GEOGRAPHY

GEOLOGY

Upcoming Events & Field Trips:

October 16-17, 2003 - Indiana Academy of Science Fall Meeting - Anderson University, Anderson, IN

November 2-5, 2003 - GSA National Meeting - Seattle, Wa
A number of our geology undergraduate and graduate students will be presenting posters at the national Geological Society of America (GSA) meeting in Seattle this November.

TBA - Mineralogy - Chicago, IL
Dr. Brake will be taking the Mineralogy class this semester to the Field Museum in Chicago.

TBA - Sedimentology/Stratigraphy - Missouri
Dr. Dutta and his Sed/Strat students will be going to Missouri in November 2003.

Past Events and Field Trips:

September 13, 2003 - GGA Pitch-in Dinner - Hawthorn Park, TH
There will be a pitch-in dinner for students and faculty in the Geography, Geology, and Anthropology Department from 3:00 to 6:00PM. More information is available at the GGA office (x2444).

April 19, 2003 - 7th Annual William A. Dando Graduate & Undergraduate Research Showcase - ISU

September 20, 2003 - San Diego Research Cruise - San Diego, CA
Two geology undergraduates went to San Diego to participate in a 24 hour research cruise. They were joined by students and faculty from the University of San Diego as well as graduate students from Scripps Institution of Oceanography.

April 12th, 2003- Paleontology/Historical Geology - Madison, IN

Dr. Brake and Dr. Rathburn and around 25 students journeyed to southern Indiana to look at a famous Paleozoic fossil deposit in Madison, IN. In addition, the main falls at Clifty Falls State Park was visited as well.

March 16-22, 2003 - Igneous and Metamorphic Petrology - New Mexico and Texas
Dr. Dreher and four petrology students ventured out to Bandalier National Monument near Los Alamos, NM. Also visited were Carlsbad Caverns and the Quadalupe Mountains in northern Texas.

ANTHROPOLOGY

Last modified: May 14, 2004

Musical Plates

A Study of Earthquakes and Plate Tectonics

Earthquakes, a scientific and physical phenomenon, affect our lives in many ways. In this project, students use Real-Time earthquake and volcano data from the Internet to explore the relationship between earthquakes, plate tectonics, and volcanoes.

Students will:

- Use Real-Time data to solve a problem.
- Study the correlation between earthquakes and tectonic plates.
- Determine whether or not there is a relationship between volcanoes and plate boundaries.

***Musical Plates* is recommended for upper elementary, middle school and high school students (ages 11-18).**

Our site is best viewed at a resolution of 800 X 600 or greater
Click HERE for instructions on how to check or change your monitor's resolution

This project is developed and managed by the Center for Innovation in Engineering and Science Education (CIESE) which is located at Stevens Institute of Technology in Hoboken, NJ. You can learn more about this and many other CIESE sponsored Internet-based educational activities by visiting http://www.k12science.org
The language arts component was developed by the Bank Street College of Education working in collaboration with CIESE staff.

National Earthquake Information Center

Tour Information

Earthquake Information Line

Seismic Networks

ANSS

Contact Us

Earthquake Information for the World

Who We Are

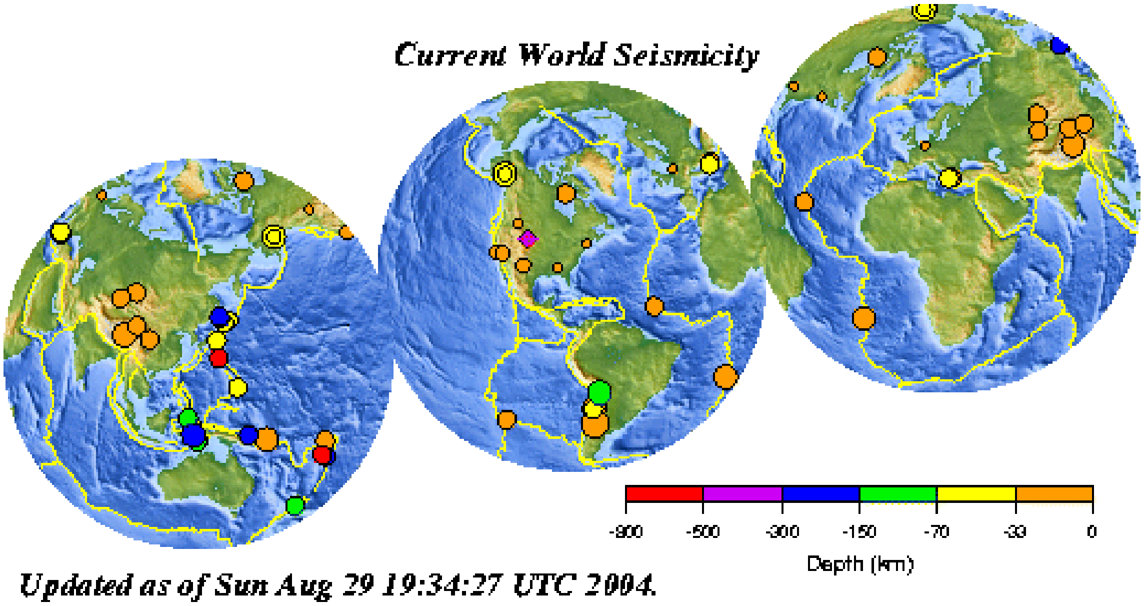
National Earthquake Information Center

The mission of the National Earthquake Information Center (NEIC) is to rapidly determine location and size of all destructive earthquakes worldwide and to immediately disseminate this information to concerned national and international agencies, scientists, and the general public. As World Data Center for Seismology, Denver, the NEIC compiles and maintains an extensive, global seismic database on earthquake parameters and their effects that serves as a solid foundation for basic and applied earth science research.

Earthquake Data Available from the NEIC

- Current Worldwide Earthquake List
- Latest Fast Moment Tensor Solutions
- Latest Energy & Broadband Solutions
- Earthquake Catalog Search
- Moment Tensor & Broadband Source Parameter Search
- AutoDRM
- Data Available Through FTP
- Routine U.S. Mining Seismicity
- International Registry of Seismograph Station
- Large Earthquakes This Year
- Earthquake Summary Posters

Earthquake Activity in the Last Seven Days



Earthquake Activity in the Last Seven Days

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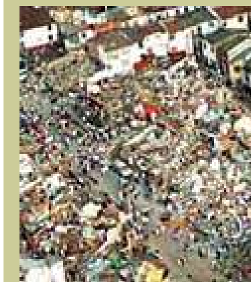
Colombians Sift Rubble as Earthquake Toll Rises
By THE ASSOCIATED PRESS



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Wednesday, January 27, 1999

Amidst the Rubble of Ruined Cities

Proposing Methods to Rebuild Colombia's Infrastructure in the Wake of a Major Earthquake

Author(s)
Alisan Zimbalist, The New York Times Learning Network

Grades: 6-8, 9-12
Subjects: Current Events, Geography, Social Studies
Interdisciplinary Connections

Overview of Lesson Plan: This lesson is designed to promote an understanding of how a natural disaster, specifically an earthquake, can devastate the essential aspects of a country's infrastructure. Students will work in committees to develop and propose solutions to rebuild various elements of Colombia's infrastructure in the wake of the January 25, 1999 earthquake, as well as compare and contrast the earthquake's affects on Colombia to the 1994 earthquake in Los Angeles.
Review the Academic Content Standards related to this lesson.

Suggested Time Allowance: 45 minutes

Objectives:
Students will:
1. Brainstorm how different aspects of a country's infrastructure would be affected by a major earthquake.
2. Assess the damage caused by the January 25, 1999, earthquake in Colombia through reading and discussing "Colombians Sift Rubble as Earthquake Toll Rises."
3. Analyze, in committees, specific aspects of Colombia's present infrastructure problems caused by the recent earthquake, devise possible solutions for these problems, and assess how each aspect of a country's infrastructure is interdependent with the others.
4. Present their committee's ideas and project ways in which the Colombian government may begin rebuilding their country.
5. Compare and contrast the featured article to an article recounting the effects of the 1994 earthquake in Los Angeles, California, by writing a reflective journal.

Resources / Materials:
-classroom blackboard
-student journals
-pens/ pencils
-paper
-copies of "Colombians Shift Rubble as Earthquake Toll Rises" (one per student)
-map of Colombia
-copies of "Awaiting Quake Aid, and Riot Aid, Too" (one per student)

Activities / Procedures:
1. WARM-UP/ DO-NOW: Students are asked to imagine that there is an enormous earthquake that devastates a major city in their state or country. The class then brainstorms about how the earthquake may affect the following aspects of the infrastructure of that country: commerce/trade, food supply, health care/disease prevention, communication/roads, shelter, power supply. The teacher writes

student responses on the board in columns (a column labeled "commerce/ trade," a column labeled "food supply," and so on). The teacher then tells students that today they will be investigating how these aspects of life in Colombia have been devastated by the earthquake that shook the country on January 25, 1999.

2. Read and discuss "Colombians Sift Rubble as Earthquake Toll Rises," focusing on the questions below. On a map of Colombia, point out the different cities that are mentioned in the article to give students a better sense of location.
a. What details provided in this article illustrate the sense of total destruction caused by January 25, 1999’s earthquake in Colombia?
b. What evidence of panic and chaos among the Colombian people is provided in the article?
c. Refer to the six elements of infrastructure discussed in the previous activity. (These should still be on the board.) How is each of these elements described in the article? What evidence is there of the destruction of each of these elements of the infrastructure of Colombia and of individual cities?
d. What aid, both from other areas of Colombia and from foreign countries, is being offered to those affected by the earthquake? What hope does this aid offer? What destruction can this aid not "buy back"?
e. How are government officials and leaders reacting to the devastation caused by the earthquake?
f. Much of the article focuses on the buildings destroyed by the earthquake. How does this physical destruction relate to the effects on the aspects of the infrastructure of the Colombian cities affected and to the effects on the people of this country?
g. What hope does the description of rescue teams and their successes offer?
h. Why is the Richter scale measurement significant in the case of this earthquake?

3. Divide students into six groups, one for each of these areas: commerce/trade, food supply, health care/disease, communication/roads, shelter, and power. Tell each group that it is a committee established to deal with a specific area of the infrastructure of Colombia being affected by the devastation caused by the recent earthquake. Each group must discuss and take notes on their answers to three questions:
--What problems exist in your specific area of the infrastructure of Colombia due to the devastation caused by the January 25, 1999, earthquake?
--What solutions can your committee propose to attempt to solve these problems?
--How does your committee's area relate to each of the other areas of the infrastructure of Colombia?
Groups should refer to the notes written on the board from the first activity and the New York Times article for assistance.

4. In round-table fashion, each committee presents its group's ideas to the class. After all committees have presented, wrap up the discussion by asking students how they think the government of Colombia will work towards rebuilding these aspects of the country.

5. WRAP-UP/ HOMEWORK: Students read "Awaiting Quake Aid, and Riot Aid, Too," a January 27, 1994, New York Times article recounting the effects of the major earthquake that shook the Los Angeles, California, area in the beginning of that year. In their journals, students write a reflective response to the article in comparison to the article read in class about the earthquake in Colombia. What are some of the essential differences between how earthquakes and other natural disasters affect lesser developed countries (like Colombia) and developed countries (like the United States)? Why do these differences exist? How is the damage noted in the Los Angeles article similar to and different from the damage noted in the Colombia article, and why? Students should share their responses in a future class.

Further Questions for Discussion:
--What areas are often hit by earthquakes, and why are these locations prime earthquake zones because of their geographical features?
--How are earthquakes forecasted, and what surveillance methods are used to watch the progress and aftershocks of earthquakes?
--How can people prepare for an earthquake?

--What forms of aid do those affected by natural disasters in the U.S. and in other countries receive? What hope does this aid offer? What destruction can this aid not "buy back"?
--What aspects of a country's infrastructure may be affected by an earthquake or other natural disaster?
--How might the size of a country affect the proportion of the population and geographic area subject to devastation and in need of aid in the event of a earthquake or other natural disaster?
--How might people living in a rural area be affected differently by a earthquake from those living in urban areas?
--What industries might be affected by major earthquakes, and why?
--How do the various elements of a country's infrastructure affect the other elements of that country's infrastructure?
--In what ways can governments rebuild their countries following a natural disaster?
--What are some of the essential differences between how earthquakes and other natural disasters affect lesser developed countries (like Colombia) and developed countries (like the United States), and why do these differences exist?

Evaluation / Assessment:
Students will be evaluated based on participation in class discussions, thoughtful participation in infrastructure "committees" and in presentation of decisions, and written journal response comparing and contrasting the effects of the earthquake in Colombia to the 1994 earthquake in Los Angeles.

Vocabulary:
accounting, surpass, devastated, epicenter, aftershock, rubble, mayhem, rendered, uninhabitable, coveted, commodity, airlifted, epidemics, ombudsman, chaos, uprising, teetering, precarious, casualties, endemic, intact, seismological

Extension Activities:
1. Diagram an earthquake timeline, noting major quakes in each continent over the past 100 years.

2. Create a map showing earthquake zones. The map may include information about where major earthquakes have struck, such as dates, financial impacts, and death tolls.

3. Search the Internet for the Web sites of organizations that assist earthquake victims in the United States and worldwide.

4. Maintain an on-going scrapbook of newspaper articles about the earthquake in Colombia. Each article should be clipped and taped to a notebook page, and students should summarize and offer opinions of the articles.

5. Organize a community aid drive for the victims of the earthquake in Colombia. Students can contact local relief organizations for support or to volunteer to participate in community efforts.

6. Learn about seismology. What prediction methods and technologies are used? How does one "track" an earthquake and its aftershocks?

7. Research other types of natural disasters (e.g., volcanoes, floods, tornadoes, tsunamis, forest fires, blizzards, droughts), focusing on how these disasters are predicted, how one can protect oneself in these disasters, and famous examples of these disasters.

Interdisciplinary Connections:
American History- Research natural disasters that have occurred in the United States and the relief organizations and government programs that assisted the victims and helped to rebuild the land and the communities. Students should also compare resources available in the United States to those currently available in Colombia.

Global History
-Learn about the country of Colombia, focusing on its government, economy, and culture.

-Investigate earthquakes that devastated other countries and research the methods that were used to rebuild these areas.

Language Arts
-Share personal experiences with natural disasters.
-Write a persuasive essay defending or refuting one country's offering of natural disaster relief to other countries.

Journalism- Maintain a photojournalism notebook of news photographs of the earthquake in Colombia. The class can also devote a bulletin board to photos and news clippings following this disaster and the relief efforts being put in place.

Mathematics:
-Create a chart comparing the economies, population, size, and other statistics about the United States and Colombia. What resources might the United States have that Colombia does not? What do these statistics demonstrate about potential differences in aid for natural disaster victims?
-Graph the frequency of major earthquakes in different countries.
-Explore logarithms by comparing the Richter and Mercalli scales, used in measuring the intensity of earthquakes.

Media Studies- Assess how the media is covering the earthquake in Colombia by keeping a daily log of news reports from television, radio, or a newspaper. How are these media covering the same event differently? If Spanish television news shows or newspapers are available in your part of the country, how are these media presenting the news about Colombia? What similarities and differences exist?

Science- Create "How It Works" posters for earthquakes, illustrating how each of the three classes of earthquakes (tectonic, volcanic, and artificially produced) are caused.

Technology- Explore how seismographs and other earthquake-tracking technologies work.

Teaching with The Times- Find articles related to the earthquake in Colombia in other sections of the newspaper, such as Business, Editorial, and Op-Ed. How do writings in these areas of the paper present information and express ideas differently?

Other Information on the Web

Earthquake Bulletin: Colombia (http://wwwneic.cr.usgs.gov/neis/bulletin/990125224018.HTML) provides data and schematics of the January 25, 1999 quake in Colombia.

National Earthquake Information Center (http://wwwneic.cr.usgs.gov/current_seismicity.shtml), from the United States Geological Survey, includes earthquake bulletins, an explanation of earthquake parameters, and maps that show recent earthquakes.

The World-Wide Earthquake Locator (http://www.geo.ed.ac.uk/quakes/quakes.html) provides basic information about earthquakes within hours of their taking place.

DisasterRelief.org (http://www.disasterrelief.org) discusses worldwide disaster aid and information.

Academic Content Standards:

McREL This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8

Geography Standard 4- Understands the physical and human characteristics of place. Benchmarks: Knows the physical characteristics of places (e.g., soils, landforms, vegetation, wildlife, climate, natural hazards); Knows how technology shapes the human and physical characteristics of places (e.g., satellite dishes, computers, road construction); Knows the causes and effects of changes in a place over time

Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmarks: Knows the major processes that shape patterns in the physical environment; Knows the consequences of a specific physical process operating on Earth's surface

Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Knows the ways in which human systems develop in response to conditions in the physical environment; Knows how the physical environment affects life in different regions; Knows the effects of natural hazards on human systems in different regions of the United States and the world; Knows the ways in which humans prepare for natural hazards

Science Standard 2- Understands basic Earth processes. Benchmarks: Knows processes involved in the rock cycle; Knows that the Earth's crust is divided into plates that move at extremely slow rates in response to movements in the mantle; Knows how land forms are created through a combination of constructive and destructive forces

Grades 9-12

Geography Standard 4- Understands the physical and human characteristics of place. Benchmarks: Knows how social, cultural, and economic processes shape the features of places (e.g., resource use, belief systems, modes of transportation and communication; major technological changes such as the agricultural and industrial revolutions; population growth and urbanization); Understands why places have specific physical and human characteristics in different parts of the world (e.g., the effects of climatic and tectonic processes, settlement and migration patterns, site and situation components); Knows the locational advantages and disadvantages of using places for different activities based on their physical characteristics

Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmarks: Understands how physical systems are dynamic and interactive; Understands how physical processes affect different regions of the United States and the world

Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Knows changes in the physical environment that have reduced the capacity of the environment to support human activity; Understands how people who live in naturally hazardous regions adapt to their environments; Knows factors that affect people's attitudes, perceptions, and responses toward natural hazards

Science Standard 2- Understands basic Earth processes. Benchmarks: Knows that throughout the rock cycle (e.g., formation, weathering, sedimentation, reformation), the total amount of material stays the same as its form changes; Understands the concept of plate tectonics; Knows effects of the movement of crustal plates

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Related Article
[Thousands Killed or Injured as a Huge Quake Rocks Turkey](#)
By EDMUND L. ANDREWS

[(Go to Article.)](#)

Wednesday, August 18, 1999

National Tragedy, Global Response

Examining the Local, National and International Effects On and Responses To the Earthquake in Turkey

Author(s)
[Alison Zimbalist, The New York Times Learning Network](#)

Grades: 6-8, 9-12
Subjects: Current Events, Geography, Media Studies, Social Studies
[Interdisciplinary Connections](#)

Overview of Lesson Plan: In this lesson, students explore how different people on local, national and international levels respond to a destructive natural disaster and the needs of its victims and how various facets of the media cover such an event, focusing specifically on the earthquake that devastated Turkey on August 17, 1999.
Review the [Academic Content Standards](#) related to this lesson.

Suggested Time Allowance: 45 minutes- 1 hour

Objectives:
Students will:
1. Determine all those in addition to the victims who are affected when a natural disaster devastates a country and develop an awareness of the different ways people and institutions are affected; categorize the responses on their lists as local, national and international.
2. Examine early news reports about the August 17, 1999 earthquake in Turkey by reading and discussing "Thousands Killed or Injured as a Huge Quake Rocks Turkey."
3. Develop a list of questions for each category (local, national and international) that students hope to be able to answer using news articles from various media sources.
4. Select a news source and obtain and obtain information from it that relates to the earthquake in Turkey; respond to the questions for each category as developed in class with information from this source; share information with the class in an ongoing media timeline project of this event.

Resources / Materials:
-student journals
-pens/pencils
-paper
-classroom blackboard
-copies of "Thousands Killed or Injured as a Huge Quake Rocks Turkey" (one per student)
-three long sheets of butcher paper, or several pieces of white poster board
-markers

Activities / Procedures:
1. WARM-UP/DO-NOW: Students respond to the following question (written on the board prior to class): "When a natural disaster devastates a country (such as the August 17, 1999 earthquake in Turkey), who is affected, directly and indirectly, and in what different ways are they affected?" While students are responding to the question, create three columns on the board, heading each column with one of the

following terms: Local, National, International. After five to ten minutes of writing, ask students to look at the columns on the board and to explain what each of these headings means in the context of this question. Then, ask students to categorize their responses to the journal question, first by explaining who is affected on a local level, then who is affected on a national level, and finally who is affected on an international level. Write down all student responses in the appropriate categories. Do not erase the board; these categories and responses will be referred to in a later activity.

2. Read and discuss "Thousands Killed or Injured as a Huge Quake Rocks Turkey," focusing on the following questions:
a. What details provided in this article convey to the reader a sense of the massive destruction to life and property caused by August 17, 1999's earthquake in Turkey? What statistics support the descriptions?
b. What examples are given of personal tragedy and loss?
c. What physical destruction is described in the article? What continued effects will this destruction have on essential systems and services (such as food supply, commerce, health care, communication, roads, shelter, and power supply) in the foreseeable future?
d. What are rescue teams doing at this point?
e. What kinds of assistance is being offered to those affected by the earthquake, both from within Turkey and from other countries? What remedies does this aid hope to offer? What destruction can this aid not "buy back"?
f. Refer to three categories of people affected by this disaster as discussed in the previous activity (These should still be on the board.). What evidence is presented in the article that points to the responses of people on the local, national and international levels?
g. Why is the Richter scale measurement significant in the case of this earthquake?

3. Explain to students that they will each be choosing one specific media source (a newspaper, a broadcast, cable or radio news program, or an Internet news site) that will provide ongoing coverage of the effects of the earthquake in Turkey and especially the responses of the local and world community. Return to the categories on the board, and as a class, develop a list of questions pertaining to each category that students hope to be able to answer using these media sources. Some questions should get at information, such as "Which countries were first to respond? What kind of aid was offered by different countries? Which were services? What kind? Which were money? How much?". Other questions might seek to understand deeper issues. For example, "What were the responses of countries that have been historic enemies of Turkey? Why do some countries offer money, while others offer services?" Facilitate the discussion when students brainstorm to ensure that a broad range of questions will be asked. Be sure that students write down all of the questions on a piece of paper, in their journals or in their class notebooks, as these questions will help them focus in on these ideas when examining the news.

4. WRAP-UP/HOMEWORK: Ask each student to select a different news source prior to leaving class. This news source must be one to which the student will have access on a daily basis over the course of the weeks following the earthquake. Some suggestions for media sources:
--national and local newspapers
--online newspapers (two Turkish newspapers that students may want to use are Turkish Daily News, found at (http://www.turkishdailynews.com/FrTDN/latest/heads.htm) and Milliyet, found at (http://www.milliyet.com.tr/e/))
--popular online newswires and news services (The Associated Press at (http://www.ap.org); Reuters at (http://www.reuters.com); the BBC at (http://www.bbc.co.uk/home/today); ITN at (http://www.itn.co.uk); CNN at (http://www.cnn.com); MSNBC at (http://www.msnbc.com))
Students should fold a paper into three columns, labeling each as labeled in class (Local, National, International). Students should select an item from their news source, and take notes in the appropriate columns based on their items, referring to

the questions developed in class as a guide and trying to answer as many questions as possible. Before students return to class the next day, post a triple time-line on wide butcher paper. The timeline should be set up with three parallel lines from left to right, so that students can record local, national and international responses to the disaster as they unfold over a period of time. In class, students should share the information learned from their articles by category, adding it to the appropriate time-line in brightly colored markers, dating each entry so that it is clear when this information was gathered. Add a brief citation to each with the student's name and the media source. As the week continues (or weeks, depending on how long you want students to work on this project), add to these time-lines of media coverage of the earthquake and its effects by following the same procedure. On a daily basis, and at the conclusion of the project, evaluate how news media differ in what, when and how information is presented, as well as how the local, national and international communities are responding to this disaster.

Further Questions for Discussion:

--What areas are often affected by earthquakes, and what is it about their locations that makes them places where earthquakes are more likely than in other places?
--Why would someone live in an area that they know is likely to sustain damage from a natural disaster such as an earthquake?
--How are earthquakes predicted, and what surveillance methods are used to watch the progress and aftershocks of earthquakes?
--How can people prepare for an earthquake?
--What forms of aid do those affected by natural disasters receive? What remedies does this aid offer? What destruction can this aid not "buy back"?
--Who determines how much aid a country will receive in the event of a natural disaster?
--Who determines how much aid a country will give to another country, and what are the considerations in making such a decision?
--What factors affect how quickly a country responds to a crisis of this sort in another country?
--What aspects of a country's infrastructure may be affected by an earthquake or other natural disaster?
--How might the size of a country affect its ability to respond to a disaster?
--How might the state of economic and technical development affect a country's response to a disaster within its borders?
--How might the political and economic systems affect a country's response to a disaster within its borders?
--How might people living in a rural area be affected differently by an earthquake from those living in urban areas?
--What industries might be affected by major earthquakes, and why?
--In what ways can governments rebuild their countries following a natural disaster?
--How can someone your age help victims of earthquakes and other natural disasters that happen in foreign countries?
--Should nations put aside their differences when one of the countries is suffering from a natural disaster? When have countries that are not allies responded to one another in this way? Do you behave this way when someone who you are not friends with or dislike needs help that you can offer?

Evaluation / Assessment:

Students' learning will be assessed based on written journal response, participation in class discussions and brainstorming exercises, and thoughtful and thorough news article analyses regarding the aftermath of the August 17, 1999 earthquake in Turkey.

Vocabulary:

archipelago, magnitude, seismologists, wreckage, debris, aftershocks, scenarios, slip-shod, Parliament

Extension Activities:

1. Examine the theory of plate tectonics and the way in which this theory explains how earthquakes are concentrated in specific areas on the Earth's surface. The National Earthquake Information Center offers this information online at (http://wwwneic.cr.usgs.gov/neis/plate_tectonics/rift_man.html). You might also

want to examine the effects that the Earth's plates have on volcanoes and tsunamis.

2. Work in small groups, each focusing on a facet of the infrastructure of a country (e.g., commerce/trade, food supply, health care/disease, communication/roads, shelter, and power) Each group serves as a "committee" established to deal with a specific area of the infrastructure of Turkey being affected by the devastation caused by the recent earthquake. Groups must discuss and take notes on their answers to three questions:
--What problems exist in your specific area of the infrastructure of Turkey due to the devastation caused by the August 17, 1999, earthquake?
--What solutions can your committee propose to attempt to solve these problems?
--How does your committee's area relate to each of the other areas of the infrastructure of Turkey?
Groups should then meet together and discuss how to rebuild the elements of the nation's infrastructure damaged or destroyed in the earthquake.

3. Diagram an illustrated earthquake timeline, noting major quakes in each continent over the past 100 years.

4. Create a three-dimensional map that shows earthquake zones. The map may also include information about where major earthquakes have struck, such as dates, Richter scale readings, death tolls and economic impacts.

5. Determine what actions students can take to support the victims of the earthquake in Turkey, and then organize an event or program to do so. Students can contact local relief organizations for support or volunteer to participate in community efforts.

6. Experiment with how the physical structure of buildings can be designed to be more earthquake-proof. Newton's Apple provides an excellent online lesson and activity that you can do at home (http://ericir.syr.edu/Projects/Newton/12/Lessons/earthquk.html).

7. Learn about seismology. What prediction methods and technologies are used? How does one "track" an earthquake and its aftershocks? Try building your own seismograph following the directions provided at (http://cse.ssl.berkeley.edu/lessons/indiv/davis/hs/Seismograph.html).

8. Find out the sensitivity of your area to natural or other large scale environmental disasters by researching the natural or commercial history of the place where you live. Then, create a disaster safety guide that discusses precautions you can take to best protect yourself and your home if disaster occurs, what to do in the case of an emergency, and the organizations that may be able to offer aid to your community.

9. Research other types of natural disasters (e.g., volcanoes, floods, tornadoes, tsunamis, forest fires, blizzards, droughts), focusing on how these disasters are predicted, how one can protect oneself during these disasters, and famous examples of these disasters.

Interdisciplinary Connections:
American History- Research natural disasters that have occurred in the United States and the relief organizations and government programs that assisted the victims and helped to rebuild the land and the communities. Students should also compare resources available in the United States to those currently available in Turkey.

Foreign Language**-** Obtain newspapers written in the language of study that include coverage of the earthquake in Turkey. Translate headlines, articles and captions. Then, write a news story in this foreign language covering the recent details of this event. Be sure to include a provocative and informative headline.

Global History
-Learn about the country of Turkey, focusing on its government, economy, and culture.
-Investigate earthquakes that devastated other countries and research the methods that were used to rebuild these areas.

Health- Investigate the health issues that can arise when a city or country is devastated by a natural disaster. Then, search the Internet for the Web sites of organizations that assist earthquake victims in the United States and worldwide. What are the missions of these various organizations? In what current efforts is each organization involved? How can someone your age lend a hand in helping the victims of earthquakes?

Language Arts
-Share personal experiences with extraordinary natural occurrences.
-Write a persuasive essay defending or refuting one country's offer of natural disaster relief to other countries.
-Compare and contrast earthquake accounts. Famous Earthquake Accounts (http://www.crustal.ucsb.edu/ics/understanding/) provide such accounts written by Mark Twain, Jack London, Charles Darwin and John Muir.

Journalism- Collect news photographs of the earthquake in Turkey. Assess the value of these photos in relaying news in ways that the written word may be unable to do.

Mathematics:
-Create a chart comparing the economies, population, size, and other statistics about the United States and Turkey. What resources might the United States have that Turkey does not? What do these statistics demonstrate about potential differences in aid for natural disaster victims?
-Graph the frequency of major earthquakes in different countries.
-Explore logarithms by comparing the Richter and Mercalli scales, used in measuring the intensity of earthquakes.

Science- Create "How It Works" posters or tabletop demonstrations about earthquakes, illustrating how each of the three classes of earthquakes (tectonic, volcanic, and artificially produced) are caused.

Technology- Explore how seismographs and other earthquake-tracking technologies work.

Other Information on the Web

National Earthquake Information Center (http://wwwneic.cr.usgs.gov/current_seismicity.shtml) from the United States Geological Survey includes earthquake bulletins, an explanation of earthquake parameters, and maps that show recent earthquakes.

The World-Wide Earthquake Locator (http://www.geo.ed.ac.uk/quakes/quakes.html) provides basic information about earthquakes within hours of their taking place.

Infoplease Spotlight: Earthquakes 101 (http://www.infoplease.com/spot/earthquake1.html) is an encyclopedia-like resource that includes links to information about key words and concepts, pages of earthquake statistics, information on seismology and a disaster quiz.

DisasterRelief.org (http://www.disasterrelief.org) discusses worldwide disaster aid.

Savage Earth: All Stressed Out (http://www.pbs.org/wnet/savageearth/earthquakes/index.html) is the companion site to the PBS program, with animations and explanations of why and how earthquakes happen.

The Museum of the City of San Francisco (http://www.sfmuseum.org/) provides a wide variety of documentation of all forms regarding the great earthquake and fire of 1906 and the 1989 San Francisco earthquake.

Academic Content Standards:

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Grades 6-8
Geography Standard 4- Understands the physical and human characteristics of place. Benchmarks: Knows the physical characteristics of places; Knows how technology shapes the human and physical characteristics of places; Knows the causes and effects of changes in a place over time
Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmarks: Knows the major processes that shape patterns in the physical environment; Knows the consequences of a specific physical process operating on Earth's surface
Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Knows the ways in which human systems develop in response to conditions in the physical environment; Knows how the physical environment affects life in different regions; Knows the effects of natural hazards on human systems in different regions of the United States and the world; Knows the ways in which humans prepare for natural hazards
Language Arts Standard 7- Demonstrates competence in the general skills and strategies for reading a variety of informational texts. Benchmarks: Applies reading skills and strategies to a variety of informational texts; Summarizes and paraphrases complex, explicit hierarchic structures in informational texts; Uses new information to adjust and extend personal knowledge base; Draws conclusions and makes inferences based on explicit and implicit information in texts

Grades 9-12
Geography Standard 4- Understands the physical and human characteristics of place. Benchmarks: Knows how social, cultural, and economic processes shape the features of places; Understands why places have specific physical and human characteristics in different parts of the world; Knows the locational advantages and disadvantages of using places for different activities based on their physical characteristics
Geography Standard 7- Knows the physical processes that shape patterns on Earth's surface. Benchmarks: Understands how physical systems are dynamic and interactive; Understands how physical processes affect different regions of the United States and the world
Geography Standard 15- Understands how physical systems affect human systems. Benchmarks: Knows changes in the physical environment that have reduced the capacity of the environment to support human activity; Understands how people who live in naturally hazardous regions adapt to their environments; Knows factors that affect people's attitudes, perceptions, and responses toward natural hazards
Language Arts Standard 7- Demonstrates competence in the general skills and strategies for reading a variety of informational texts. Benchmarks: Applies reading skills and strategies to a variety of informational texts; Summarizes and paraphrases complex, implicit hierarchic structures in informational texts, including the relationships among the concepts and details in those structures; Uses new information from texts to clarify or refine understanding of academic concepts; Evaluates the clarity and accuracy of information

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Related Article
Turk Minister Criticizes Government's Response to Quake
By STEPHEN KINZER

(Go to Article.)

Wednesday, August 25, 1999

Outreach in the Aftermath

Understanding the Importance of Providing Aid to Victims of Natural Disasters

Author(s)
Alison Zimbalist, The New York Times Learning Network

Grades: 6-8, 9-12
Subjects: Current Events, Geography, Language Arts, Social Studies
Interdisciplinary Connections

Overview of Lesson Plan: In this lesson, students investigate the many types of aid needed to help Turkey recover and rebuild in the wake of the earthquake that devastated a large portion of the country on August 17, 1999. Students then create a plan for a fundraiser or project that they can do to offer assistance to the victims of this disaster.

Review the Academic Content Standards related to this lesson.

Suggested Time Allowance: 1 hour

Objectives:
Students will:
1. Brainstorm how different aspects of a city's infrastructure would be affected by a very destructive natural disaster; analyze the types of aid that would help rebuild in the wake of this disaster, as well as whose responsibility it is to give such aid.
2. Examine how the Turkish government has responded to the August 17, 1999 earthquake there and understand differing reactions about this response by reading and discussing "Turk Minister Criticizes Government's Response to Quake."
3. List the many types of aid from which Turkey could benefit in the wake of the earthquake; determine which of these types of aid the students in your class could offer; develop a basic plan for a project that they could actually organize and execute in order to provide aid to the victims of this earthquake.
4. Express whether they feel that it is important to participate in an international aid project like the one organized in class and predict how they would respond if a friend asked what someone their age can do to help victims of natural disasters in other countries.

Resources / Materials:
-pens/pencils
-paper
-classroom blackboard
-copies of "Turk Minister Criticizes Government's Response to Quake" (one per student)

Activities / Procedures:
1. WARM-UP/DO-NOW: Prior to class, arrange desks into groups of three or four, and write the following scenario on the board for students to respond to as a group upon entering class (one student in each group should act as the secretary and write down the group's responses): Your city has been hit with one of the worst (insert a natural disaster that may occur in your city, such as tornado, blizzard, flood, hurricane, earthquake, etc.)s it has ever seen. When you come out of your home, you realize that this disaster has wreaked total havoc as far as your eyes can see.

How do you expect the following aspects of the infrastructure of your city to have been affected by this disaster?: commerce/trade, food supply, health care/disease prevention, communication/roads, shelter, power supply. How will your city be able to rebuild? Who might offer aid to you, and in what form might that aid be given? After ten to fifteen minutes, ask a spokesperson from each group to share their responses. Then discuss in what ways, if at all, the government of a country that is suffering in the aftermath of a natural disaster should lend aid to the citizens. Who else do students think has a responsibility to offer aid in these events?

2. As a class, read and discuss "Turk Minister Criticizes Government's Response to Quake," focusing on the following questions:
a. What did Tourism Minister Erkan Mumcu mean by referring to the response of Turkey's government to the August 17, 1999 earthquake as "'a declaration of bankruptcy for the Turkish political and economic system'"? What did Mr. Mumcu mean when he said that "'lying under the ruins is the Turkish political and administrative system'?
b. What is Mr. Yasar's argument with regards to the Government's poor response to the earthquake?
c. What steps did President Demirel say the Government would take to better strengthen Turkey for the possibility of future earthquakes? What was unusual, on a personal level, about his statement?
d. What did the news commentator quoted in the article mean by saying that "'the millennium came to Turkey a year before other countries'"?
e. Why has Health Minister Osman Durmus been so heavily criticized in the wake of the earthquake?
f. What is the purpose of including the story of Ismail Cimen's discovery and rescue in this article?
g. How is the Turkish military helping the victims of the earthquake?
h. How are other countries aiding the victims?
i. What health issues have arisen in Turkey because of the earthquake, and how are they being handled?

3. Brainstorm on the board the many types of aid from which Turkey could benefit in the wake of the August 17, 1999 earthquake, keeping in mind the aspects of infrastructure examined in the initial classroom exercise. Then, determine which of these types of aid the students in your class could offer, and circle them on the board. Tell students that they will now be developing a basic plan for a project that they could actually organize and execute in order to provide aid to the victims of this earthquake. (The simpler the plan, the more likely students will want to carry it out.) First, vote on which kind of aid they would want to provide (financial, clothes, first aid supplies, etc.). Once this is decided, discuss the following questions regarding the planning and execution of this fundraiser or project, and ask students to take notes of the class's responses to them:
--How will you raise funds or gather the materials you are collecting for this project?
--For how long (weeks, months) do you want this collection to occur?
--What adults will need to help you with this project, and how?
--What other students will need to help you with this project, and how?
--Where will this fundraiser or collection of items take place, and why is this location a good choice? Who will you need to contact about making arrangements to use this place?
--What materials will you need for this project? (What you will be selling, as well as other equipment such as a table or posters explaining the project?)
--How and where will you advertise this fundraiser or project?
--What is the name of the fundraiser or project?
--Where will you send the money raised or items gathered through the project?
With your help as the sponsor of this project, students may want to put there plan into action. Future class periods and after-school sessions can be devoted to making sure that this plan works and that students will be successful in raising money or collecting items that will be sent to the victims of the earthquake in Turkey.

4. WRAP-UP/HOMEWORK: In their journals, students respond to the following

questions: Do you feel that it is important for you to participate in an international aid project like the one organized in class, and why? If a friend asked you what someone your age can do to help victims of natural disasters in other countries, what would you say?

Further Questions for Discussion:

--What areas are often affected by earthquakes, and what is it about their locations that makes them places where earthquakes are more likely than in other places?
--Why would someone live in an area that they know is likely to sustain damage from a natural disaster such as an earthquake?
--How are earthquakes predicted, and what surveillance methods are used to watch the progress and aftershocks of earthquakes?
--How can people prepare for an earthquake?
--What forms of aid do those affected by natural disasters receive? What remedies does this aid offer? What destruction can this aid not "buy back"?
--Who determines how much aid a country will receive in the event of a natural disaster?
--Who determines how much aid a country will give to another country, and what are the considerations in making such a decision?
--What factors affect how quickly a country responds to a crisis of this sort in another country?
--How might the size of a country affect its ability to respond to a disaster?
--How might the state of economic and technical development affect a country's response to a disaster within its borders?
--How might the political and economic systems affect a country's response to a disaster within its borders?
--How might people living in a rural area be affected differently by an earthquake from those living in urban areas?
--What industries might be affected by major earthquakes, and why?
--In what ways can governments rebuild their countries following a natural disaster?
--Should nations put aside their differences when one of the countries is suffering from a natural disaster? What are some examples of countries that are not allies responding to one another in this way? Do you behave this way when someone who you are not friends with or dislike needs help that you can offer?

Evaluation / Assessment:

Students will be evaluated based on thoughtful participation in small group work, participation in class discussions, and written journal response reflecting on the importance of giving aid to victims of natural disasters.

Vocabulary:

bankruptcy, defensive, ideological, chastened, seismologists, infallible, customary, faltering, infuriated, elite, ridiculed, sanitary, dehydrate, epidemic, provision, commemoration

Extension Activities:

1. Follow the news about the earthquake in Turkey on a daily basis, creating a scrapbook or collage of articles, headlines and photographs from The New York Times or other newspapers. What efforts are being made each day to rescue the victims of this earthquake? What new information comes to light, and how are various people at the local, national and international levels reacting to this disaster as Turkey begins the slow process of rebuilding its demolished areas?

2. Work in small groups, each focusing on a facet of the infrastructure of a country (e.g., commerce/trade, food supply, health care/disease, communication/roads, shelter, and power). Each group serves as a "committee" established to deal with a specific area of the infrastructure of Turkey being affected by the devastation caused by the recent earthquake. Groups must discuss and take notes on their answers to three questions:
--What problems exist in your specific area of the infrastructure of Turkey due to the devastation caused by the August 17, 1999, earthquake?
--What solutions can your committee propose to attempt to solve these problems?
--How does your committee's area relate to each of the other areas of the infrastructure of Turkey?

Groups should then meet together and discuss how to rebuild the elements of the nation's infrastructure damaged or destroyed in the earthquake.

3. Diagram an illustrated earthquake timeline, noting major quakes in each continent over the past 100 years. Then, research the methods that were used to rebuild these areas.

4. Create a three-dimensional map that shows earthquake zones. The map may also include information about where major earthquakes have struck, such as dates, Richter scale readings, death tolls and economic impacts.

5. Research an organization or agency that is assisting the victims of the earthquake in Turkey. When, where, and why was the organization founded? Who was the founder? What services did the organization originally provide, and what does the organization do now?

6. Experiment with how the physical structure of buildings can be designed to be more earthquake-proof. Newton's Apple provides an excellent online lesson and activity that you can do at home (http://ericir.syr.edu/Projects/Newton/12/Lessons/earthquk.html).

7. Find out the sensitivity of your area to natural or other large scale environmental disasters by researching the natural or commercial history of the place where you live. Then, create a disaster safety guide that discusses precautions you can take to best protect yourself and your home if disaster occurs, what to do in the case of an emergency, and the organizations that may be able to offer aid to your community.

8. Learn about the country of Turkey, focusing on its government, economy, and culture.

Interdisciplinary Connections:
American History- Research natural disasters that have occurred in the United States and the relief organizations and government programs that assisted the victims and helped to rebuild the land and the communities. Students should also compare resources available in the United States to those currently available in Turkey.

Foreign Language- Obtain newspapers written in the language of study that include coverage of the earthquake in Turkey. Translate headlines, articles and captions. Then, write a news story in this foreign language covering the recent details of this event. Be sure to include a provocative and informative headline.

Health- Investigate the health issues that can arise when a city or country is devastated by a natural disaster. Then, search the Internet for the Web sites of organizations that assist earthquake victims in the United States and worldwide. What are the missions of these various organizations? In what current efforts is each organization involved? How can someone your age lend a hand in helping the victims of earthquakes?

Language Arts- Compare and contrast earthquake accounts. Famous Earthquake Accounts (http://www.crustal.ucsb.edu/ics/understanding/) provide such accounts written by Mark Twain, Jack London, Charles Darwin and John Muir. The Museum of the City of San Francisco (http://www.sfmuseum.org/) provides a wide variety of documentation of all forms regarding the great earthquake and fire of 1906 and the 1989 San Francisco earthquake.

Journalism- Collect news photographs of the earthquake in Turkey. Assess the value of these photos in relaying news in ways that the written word may be unable to do.

Mathematics:
-Create a chart comparing the economies, population, size, and other statistics about the United States and Turkey. What resources might the United States have that Turkey does not? What do these statistics demonstrate about potential differences in aid for natural disaster victims?
-Graph the frequency of major earthquakes in different countries.

-Explore logarithms by comparing the Richter and Mercalli scales, used in measuring the intensity of earthquakes.

Science- Create "How It Works" posters or tabletop demonstrations about earthquakes, illustrating how each of the three classes of earthquakes (tectonic, volcanic, and artificially produced) are caused.

Technology- Explore how seismographs and other earthquake-tracking technologies work. Try building your own seismograph following the directions provided at (http://cse.ssl.berkeley.edu/lessons/indiv/davis/hs/Seismograph.html).

Other Information on the Web

Earthquakes: The Sudden Killer (http://www.policy.com/news/dbrief/dbriefarc309.asp) is a briefing from Policy.com on the quake that hit Turkey, including information on international aid efforts and on preventing quake damage.

ReliefWeb: Turkey Earthquake (http://wwwnotes.reliefweb.int/) is a collection of news stories and official announcements on the quake and relief efforts.

National Earthquake Information Center (http://wwwneic.cr.usgs.gov/current_seismicity.shtml) from the United States Geological Survey includes earthquake bulletins, an explanation of earthquake parameters, and maps that show recent earthquakes.

Infoplease Spotlight: Earthquakes 101 (http://www.infoplease.com/spot/earthquake1.html) is an encyclopedia-like resource that includes links to information about key words and concepts, pages of earthquake statistics, information on seismology and a disaster quiz.

DisasterRelief.org (http://www.disasterrelief.org) discusses worldwide disaster aid.

Savage Earth: All Stressed Out (http://www.pbs.org/wnet/savageearth/earthquakes/index.html) is the companion site to the PBS program, with animations and explanations of why and how earthquakes happen.

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Language Arts Standard 8- Demonstrates competence in speaking and listening as tools for learning. Benchmarks: Plays a variety of roles in group discussions; Asks

questions to seek elaboration and clarification of ideas

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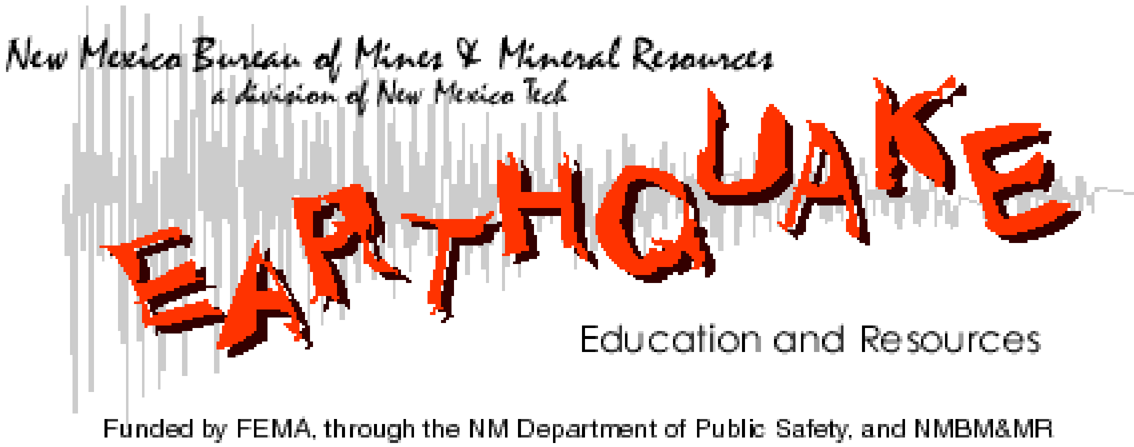


Origami Activities

Basic geometric forms such as cubes, octahedra, rhombohedra, and tetrahedra may be made by folding flat paper or envelopes, both reasonably priced starting materials. These may be used to help visualize solid forms in crystallography and mineralogy and numbers of them may be used to create unit cells. Tetrahedra in particular are easy to make by folding and cutting small envelopes. Tetrahedra may be linked to build silicate and carbonate crystal models.

A ring of six tetrahedra may be linked along two sides of each to form a hexaflexagon (Spillhaus, 1985). Spillhaus and the GeoLearning Corporation have produced hexaflexagons with illustrated geographic, geologic, and astronomic themes on each side printed on stiff paper. These models are also reasonably priced and require assembly.

As an alternative, we have combined the rapid production of tetrahedra from envelopes with various geological themes printed in color on hexagons to produce customized hexaflexagons covering the topics of earthquakes, plate tectonics, and geology of New Mexico.

To make your own hexaflexagon with earthquake-education themes, you'll need to do three things:

- First, read the instructions and make six paper tetrahedra.
- Second, download graphics files containing earthquake-education illustrations.
- Third, follow the instructions to combine the tetrahedra and the illustrations into your own hexaflexagon.

Activities page
back to tremor home

Created by Dave Love and Bill Haneberg
Last updated 5 April 1999

Earthquakes Canada - West

Current Earthquake Activity
Earthquake Maps
Seismic Data
Earthquake Hazard
Personnel & Publications
Related Information
Earthquakes Canada Home

Aug.21 11:06 & 11:13pm PDT: A M=3.7 earthquake & M=3.2 aftershock occurred in Hecate Strait.Click here for map.

Aug.03 6:14pm PDT: A M=5.1 earthquake occurred on the B.C.-Alaska border. Click here for map.

Aug.02 10:22pm & 11:32pm PDT: A M=3.1 and a M=2.8 earthquake occurred in Georgia Strait, B.C. Click here for map.

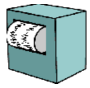
July 30 5:35pm PDT: A M=4.5 earthquake on the west coast of Moresby Island, on the Queen Charlotte Fault. It was felt in the Queen Charlotte Islands Region. Click here for map.

July 19 1:01am PDT: A M=6.4 earthquake occurred off the west coast of Vancouver Island, near Nootka Island. It was felt across Vancouver Island and on parts of the B.C. mainland. There have been hundreds of aftershocks. Click here for map.

Your comments on our webservice are appreciated! click here
See the comments... Click here

Did you feel an earthquake? Click here...

Recent Earthquakes	Historic Earthquakes
* Recent Earthquake Activity * Episodic Tremor + Slip NEW * Most Recent Significant * Maps and Lists * Felt Events 1995-present	* Damaging Earthquakes * Subduction Earthquakes * Large Earthquakes (map) * Earthquakes in Canada



Seismographs & Seismic Data

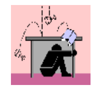
* *Live* Seismic Data
* How we record earthquakes
* Seismograph Network
* Request waveform data
* Strong Motion Network

Earthquake Hazard

* Seismic Hazard Maps
* National Building Code
* Hazard Calculations
* Trial Hazard Maps

Personnel & Publications

* Personnel
* Publications
* Recent Abstracts
* Downloadable Documents



General Information

* All About Earthquakes!
* Teachers Corner
* Quakes & Plate Tectonics
* Earthquake Preparedness
* Links to Related Websites

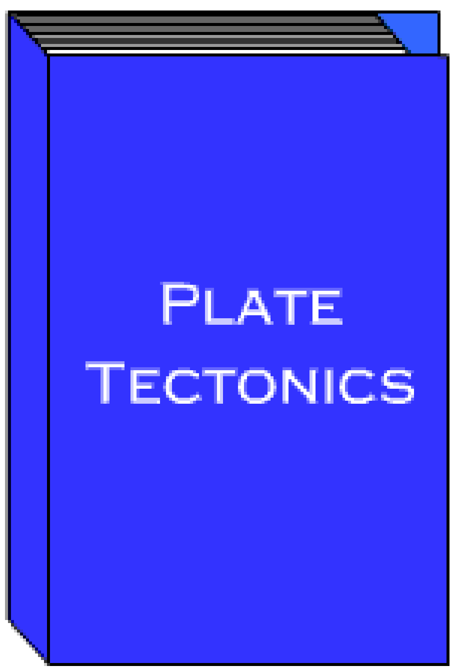
2002-12-07

Geological Survey of Canada - Sidney Subdivision
Box 6000, Sidney, BC Canada V8L 4B2
Tel: (250)363-6500 Fax:(250)363-6565

Important notices

Forces in the Earth cause its surface to change over time.

Click on the name to open the book and read more about the subject



Structure of the Earth → History of plate tectonics → Plates → Plate boundaries → Forces in the Earth → Faults → Hypercard Resources

Plate Tectonics Activities

References

Fowler, C.M.R. 1990. *The Solid Earth: An Introduction to Global Geophysics.* Cambridge University Press, New York, 472 p.

Tarbuck, E.J. and F.K. Lutgens. 1996. *Earth: An Introduction to Physical Geology, Fifth Edition.* Prentice Hall, Upper Saddle River, New Jersey, 605 p.

Twiss, R.J. and E.M. Moores. 1992. *Structural Geology.* W.H. Freeman and Company, New York, 532 p.

Title Page SCIGN EDUCATION MODULE Table of Contents

Last modified on 8/13/98 by Maggi Glasscoe (scignedu@jpl.nasa.gov)

Earth: All Stressed Out

by Daniel Pendick

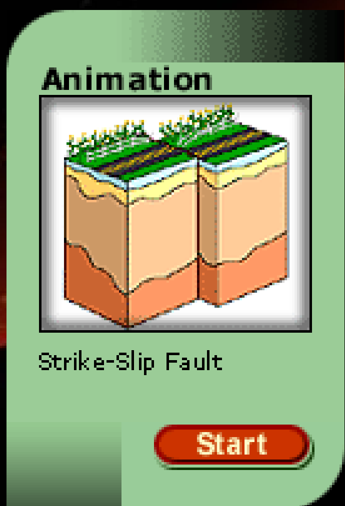
To experience the drama of plate tectonics -- the jostling of the giant plates that carry continents and oceans -- try this experiment: Sit in a comfortable chair, hold your hand out, and watch your fingernails grow. That's about the average speed of a tectonic plate. But wait around long enough, and even the tortoise crawl of plate tectonics will have dramatic and deadly consequences. Though plate tectonics is a global phenomenon and virtually invisible to us in our daily lives, it introduces enormous stresses in the crust where we live. From time to time, stressed-out crust releases the stress in sudden fits: earthquakes.

More frequently than time to time, actually. If you imagine the Earth as a giant bell, it's ringing with earthquakes every second of the day -- from the many imperceptible clinks of microquakes to the deafening gong of very occasional but "great" earthquakes (those of magnitude 8.0 or greater). The U.S. Geological Survey estimates that several million temblors, most undetectable, happen every day.

The great earthquake of 1906 devastated San Francisco, killing 700.

Most earthquakes happen near the boundaries of tectonic plates, both where the plates spread apart and where they crunch or grind together (although large temblors also strike from time to time in the normally stable interior of continents). Along plate boundaries, the brittle outer part of the Earth fractures along faults. As plates move, blocks of crust shift along the faults. The infamous San Andreas fault is not a single crack where the North American and Pacific plates slide past each other. It's the largest of a thicket of faults that collectively absorb the motion of the plates.

There are various kinds of faults that do the day-to-day dirty work of plate tectonics. The San Andreas is a "strike-slip" fault. (See animation below.) Along this seam, the plates slide past each other like cars traveling opposite directions on a highway. The other major family of faults are called "dip-slip" faults. (See animation below.) On these, blocks of crust either push together or pull apart, with one block sliding either up or down a sloped fault plane. The fault that let loose the 1994 Northridge earthquake was a dip-slip fault, at which a block of crust slid up the shallow ramp of another.



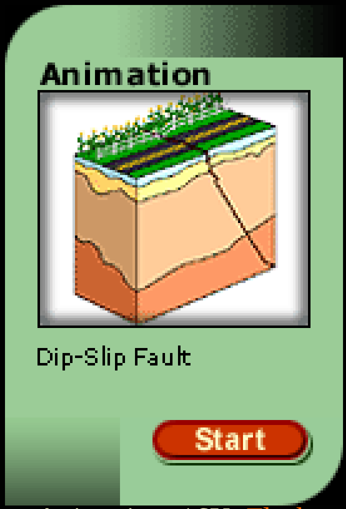
Flash animation, 20K.
You will need the free Flash plug-in
to view this animation.

Stress builds up in fault zones when crustal blocks stick together. In fact, faults are stuck, or "locked," most of the time, although some also show slow, barely detectable slippage called "aseismic creep." The important distinction for people between the different kinds of slip has to do with that word, seismic, from the Greek for "shaking." Fault creep is aseismic (that is, not seismic) because it doesn't generate vibrations in the crust called seismic waves. But when a fault is stuck, the rocks on either side of it store the building stresses until a critical limit is reached, and the rocks move suddenly along the fault, releasing the stresses like a spring uncoiling. This pumps seismic waves into the surrounding rock. (See Earthquake! animation, 5K. You will need the free Flash plug-in to view this animation.)

Seismic energy travels through the crust in the form of waves. There are two basic kinds of seismic waves: body waves and surface waves. Body waves travel outward in all directions, including downward, from the quake's focus -- that is, the particular spot where the fault first began to rupture. Surface waves, by contrast, are confined to the upper few hundred miles of the crust. They travel parallel to the surface, like ripples on the surface of a pond. They are also slower than body waves.

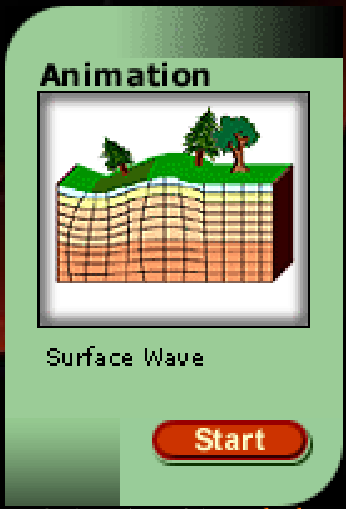
Following an earthquake, the body waves strike first. The fastest kind are the primary waves, or P-waves. (See animation below.) People often report a sound like a train just before they feel a quake, which is the P-wave moving as an acoustic wave in the air. Then the secondary, or S-waves, arrive. (See animation below.)

A person in a building perceives the arrival of S-waves as a sudden powerful jolt, as if a giant has pounded his fist down on the roof. Finally, the surface waves strike. In very strong earthquakes, the up-and-down and back-and-forth motions caused by surface waves can make the ground appear to roll like the surface of the ocean, and can literally topple buildings over. (See animation below.)

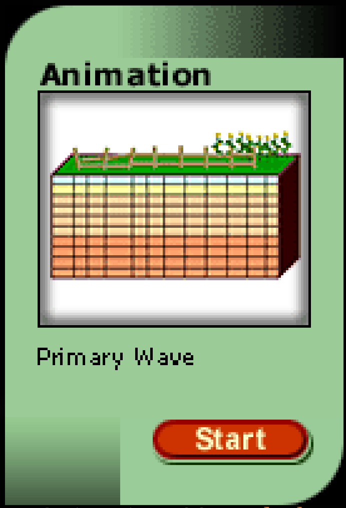


Animation, 16K. Flash required.

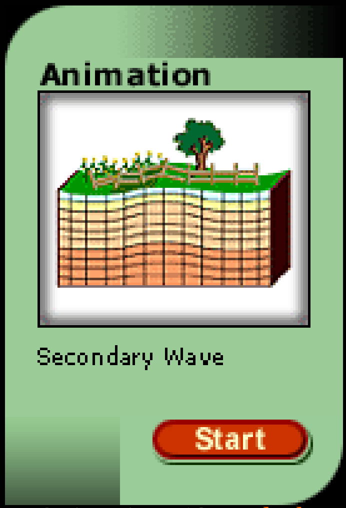
Seismologists have developed various ways to measure the strength of earthquakes. The first and most well-known is the Richter magnitude scale, developed earlier this century by California seismologist Charles Richter. The calculation of Richter magnitude is based on the maximum strength of the vibrations (measured by a seismograph) and the distance of the instrument from the epicenter of the earthquake. The Richter scale is logarithmic, which means that each increase in magnitude indicates a tenfold increase in the strength of the quake. A magnitude-6.0 earthquake, for instance, is ten times stronger than a magnitude-5.0. In terms of the energy released, the differences are even greater. A magnitude-6.0 earthquake releases 32 times the seismic energy as a magnitude-5.0.



Animation, 21K. Flash required.



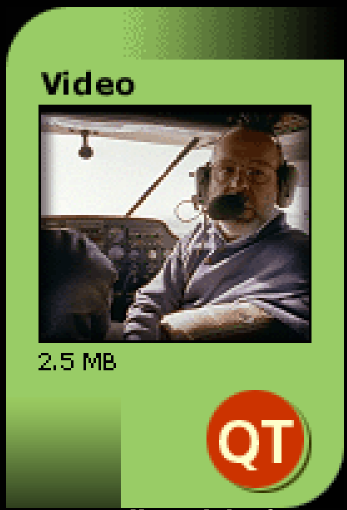
Animation, 22K. Flash required.



Animation, 13K. Flash required.

But Richter magnitude is only accurate for earthquakes up to about 310 miles (500 kilometers) from the instrument that detects it. Seismologists have developed other magnitude scales based on measurements of body waves or surface waves. But these, too, are not accurate for all earthquakes. Body-wave magnitudes, for example, aren't accurate for very strong earthquakes. Another system has come into wide use, called "moment magnitude," which takes into account the actual area of fault ruptured and gives a more consistent measure of earthquake size across the spectrum -- from minor jiggles to devastating jolts.

Seismic waves weaken with increasing distance. All things being equal, the strongest groundshaking occurs at the epicenter of the quake -- the point on the surface directly above the focus of the earthquake. (The focus can be a few miles below the ground or, more rarely, as deep as 435 miles. Beyond that depth, rocks are too hot and malleable to store strain, and they simply deform, like a block of soft clay.) In the most powerful earthquakes, groundshaking can actually exceed the acceleration of gravity and toss boulders into the air, as happened during the great Assam (India) earthquake of 1897.



You will need the free QuickTime (2.0 or above) plug-in to view this movie.
The 1989 Loma Prieta quake.

Groundshaking is not the only hazard people face during earthquakes. They can also trigger landslides. In 1692, the town of Port Royal, Jamaica, slid into the sea and came to rest 50 feet below the surface. Marine sediment quickly entombed the town, turning it into an undersea Pompeii: In 1959, archaeologists found a pot of turtle soup in one buried home, still sitting in its copper kettle. During quakes, blocks of crust also shift along fault lines, either horizontally or vertically. During the 1906 San Francisco earthquake, the west side of the San Andreas fault slid 21 feet northward. During the 1964 Alaska quake, some points on dry land rose nearly 40 feet and parts of the seafloor dropped 50 feet.

Another hazard is liquefaction. This happens when loose, moist soil or sand is shaken so hard that individual grains separate, turning the earth into a soft, fluid slurry that can swallow entire buildings. And ground motions in regions of soft sediment are drastically amplified relative to surrounding areas, so that much greater earthquake damage results, such as that in the Marina District of San Francisco following the 1906 and Loma Prieta (1989) earthquakes. The port zone of Kobe, Japan, was also damaged severely by liquefaction during the 1995 earthquake.

Though some scientists dream of discovering warning signals that would allow the evacuation of a city just before a large earthquake, the focus of earthquake preparation today is on making sure that buildings and other structures are engineered to withstand the maximum likely shaking without collapsing completely. So, if it's not possible to prevent earthquakes or flee from them, there's still hope of minimizing the death and destruction they visit on the cities of a restless and jittery planet.

SHAKE, RATTLE AND ROLL

Designing for Adversity

A building is conceived

when designed, born

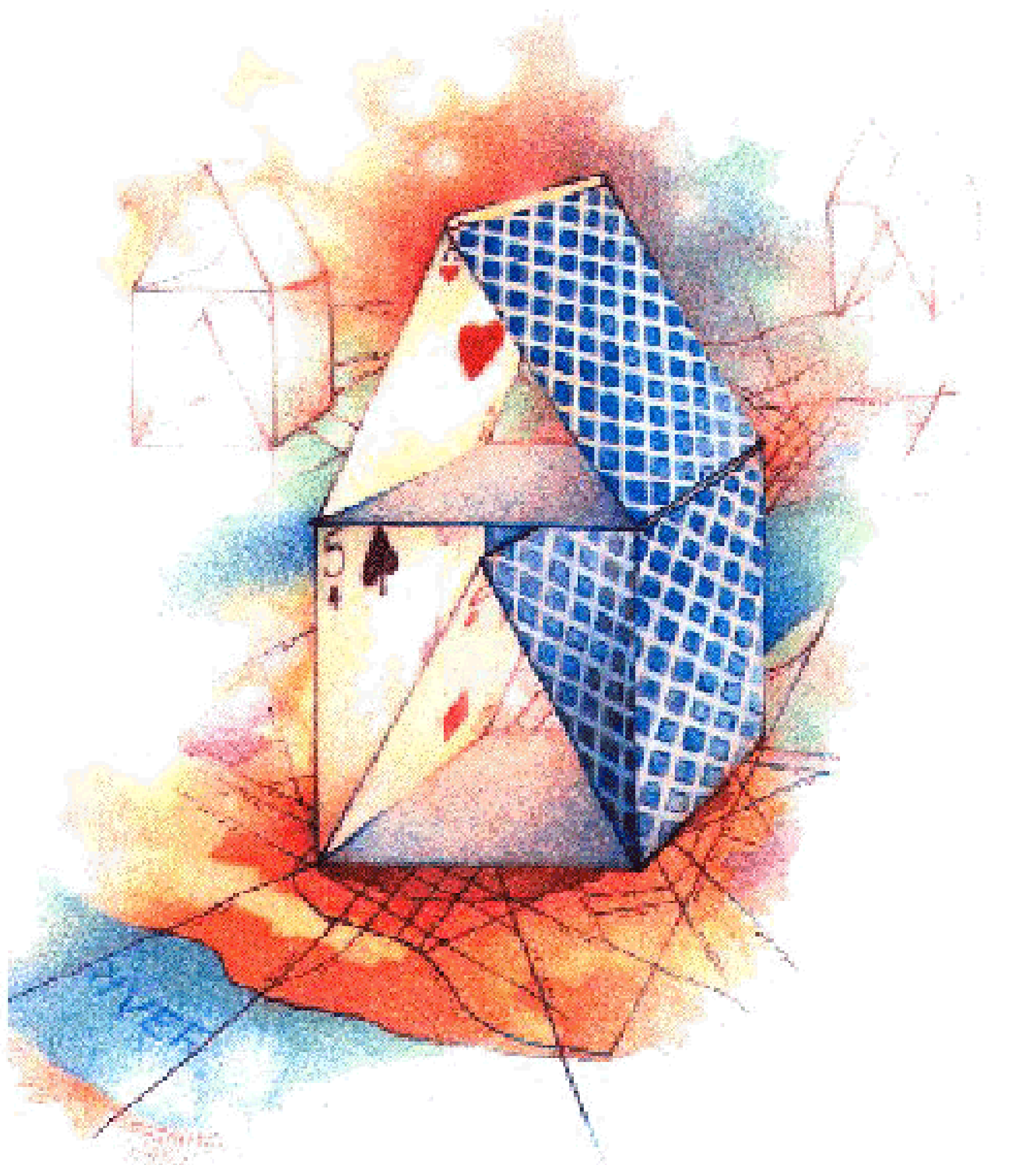
when built, alive while

standing, and dead

from old age or

unexpected accident.

--Mario Salvadori



Youngsters explore basic principles of structural design and material strength to discover effective ways to construct buildings that can withstand earthquakes. They then design a series of experiments to explore the relationship between the type of ground a structure is built on and the degree of damage it is likely to sustain in an earthquake.

Suggested Age Level: 8 through 15

SKILLS

- Observing
- Designing Fair Tests
- Comparing
- Inferring
- Predicting
- Interpreting Data
- Recording Data
- Map Reading

- Risk Assessment

SUBJECT AREAS

- Geology
- Design and Technology
- Physics
- Geography

ESTIMATED TIME

- Activity 1. Three 45-minute Sessions
- Activity 2. One 60-minute Session

Background Activity 1 Activity 2 Home and Community Connection

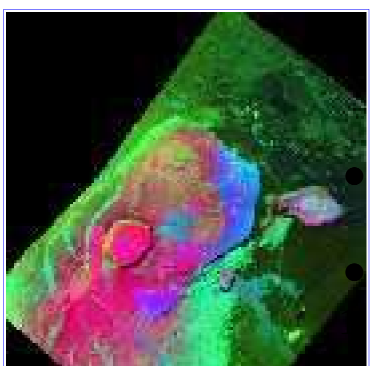
Design Connections Table of Contents SHAKE, RATTLE & ROLL

CONNECTIONS DESIGN THROUGH SCIENCE AND TECHNOLOGY

Surfing for Earthquakes and Volcanoes

by Patty Coe and Michael Merrick

- **Grade Levels:** 6 through 8
- **Time Requirements:**
  - Approx. **2-3 hours** Prep Time and **5 40-minute periods** Class Time (depending on computer experience and knowledge of Earth Sciences)
- **Student Pre-requisites:**
  1. Mapping skills, including latitude/longitude, scale and distance.
  2. Internet research skills.
  3. Knowledge of the theory of continental drift and plate boundary interactions.
- **Topics Covered by This Lesson:** Surfing the Internet; Volcanoes; Earthquakes; Plate Tectonics



- **Brief Overview:** Students use the Internet to research data on earthquakes and volcanoes and plot locations to determine continental plate boundaries. Extensions include interpretation of interaction between plate boundaries, causes of earthquakes and volcanoes, and the comparison of the formation of Olympus Mons on Mars and the Hawaiian volcanic chain.
- **Unit Features:** This lesson contains tailored worksheets and uses unique Internet images and information.
- **Materials:**
  1. Computer with access to WWW and printer.
  2. Worksheets (Masters included)

Go To The Lesson Plan Content

(Last Update: October 19, 2001)

This Lesson's Objectives	

Center for Science Education   Science Education Gateway

Mail comments to outreach@ssl.berkeley.edu

Provided by: The Pacific Northwest Seismograph Network

Seismosurfing the Internet for Earthquake Data - Expanded Version

Web connections to original seismic data or seismic research information.
See the end of the list for several other indexes to related fields.

Provided by: Steve Malone; Last updated Apr 27, 2004
Assistance from Femke Goutbeek and Torild van Eck of ORFEUS is greatly appreciated

Please send e-mail to steve@ess.washington.edu with suggested updates to this list.
NOTE: The complete SeismoSurfing index is now being mirrored for European users by ETH, Zurich at

http://www.seismo.ethz.ch/seismosurf/seismobig.html.

Special News Items:

URL addresses that have blue dots before them indicate that other interfaces are available for data viewing and/or retrieval.
Click to see an expanded listing of IP addresses for ftp, finger, and bulletin board interfaces. bulletin boards....

Quick links to sections below:

Global - California - Alaska & PNW - Inter-mountain US - Eastern US - Americas - Europe - Africa, Asia & Oceania - Volcanos - Others -

Global or composite earthquake information, research or special services

Advanced National Seismic System (US):

http://www.anss.org

ANSS authoritative composite catalog:

http://quake.geo.berkeley.edu/anss

The Consortium of Organizations for Strong-Motion Observation Systems (COSMOS)

http://www.cosmos-eq.org /DD>

Customized phase arrival-time calculator (by: USGS and University of Alaska)

http://www.giseis.alaska.edu/Input/lahr/artim.html

CTBT Prototype International Data Centre

http://www.pidc.org

Geotechnical Engineering Web Resources

http://www.uiuc.edu/ph/www/smadi

International Association of Seismology and Physics of the Earth's Interior (IASPEI):

http://www.iaspei.org

International Seismological Centre, United Kingdom:

http://www.isc.ac.uk

IRIS Headquarters: http://www.iris.edu

Data Management Center, - Global Seismograph Network, - IRIS PASSCAL Center, - Education and Outreach.

Multidisciplinary Center For Earthquake Engineering Research (MCEER):

http://mceer.buffalo.edu

NOAA - National Geophysical Data Center - Earthquake Data

http://www.ngdc.noaa.gov/seg/hazard/earthqk.shtml

USGS - National Strong Motion Program:
http://nsmp.wr.usgs.gov

USGS National Earthquake Information Center (NEIC):
http://neic.usgs.gov
US National Seismic Net: http://neic.usgs.gov/neis/usnsn/usnsn_home.html
Earthquake Hazards Program: http://earthquake.usgs.gov

Swiss Seismological Service list of world-wide AutoDRM sites (originator of the AutoDRM):
http://www.seismo.ethz.ch/waves4u

UCSD IDA/IRIS:
http://ida.ucsd.edu

SURFING THE INTERNET FOR STRONG MOTION DATA (provided by Dave Wald):
http://pasadena.wr.usgs.gov/smdata.html

Reference list to seismology software available on the Internet (provided by ORFEUS):
http://orfeus.knmi.nl/other.services/network.shtml

California Institutions.

U.C. Berkeley Seismograph Station:
http://www.seismo.berkeley.edu/seismo/Homepage.html

Bay Area Government Online (ABAG) earthquake information:
http://www.abag.ca.gov/bayarea/eqmaps/eqmaps.html

California Division of Mines and Geology, includes SMIP data
http://www.consrv.ca.gov/dmg

Caltech Seismology Lab:
http://www.gps.caltech.edu/seismo/seismo.page.html

Earthquake Engineering Research Center, UC Berkeley:
http://eerc.berkeley.edu

EQE International (Engineering information):
http://www.eqe.com/publications/index.html

Geotechnical Earthquake Engineering Server at USC:
http://geoinfo.usc.edu/gees/

Earthquake Engineering at USC:
http://www.usc.edu/dept/civil_eng/Earthquake_eng

Humboldt State University, Geology:
http://sorrel.humboldt.edu/~geodept/earthquakes/eqk_info.html

Lawrence Livermore National Laboratory - Geologic Hazards Projects
http://www.llnl.gov/hmc

Northern Calif. Earthquake Data Center (NCEDE, UC Berkeley/USGS):
http://quake.geo.berkeley.edu

Public Seismic Network (San Fransisco area):
http://psn.quake.net

Southern California Earthquake Center - Main Page
http://www.scec.org

Southern California Earthquake Data Center@Caltech (SCEC):
http://www.scecdc.scec.org

U.C. Santa Barbara Institute for Crustal Studies:
http://www.crustal.ucsb.edu

Univ. of Southern California, Geophysics Program:
http://www.usc.edu/dept/earth/research/

Southern California Earthquake Center@UCLA (SCEC):
http://scec.ess.ucla.edu

Stanford University:
http://pangea.stanford.edu/~beroza/seismo.html

UCSD ANZA and other network:
http://eqinfo.ucsd.edu

USGS Menlo Park (northern Calif):
http://quake.wr.usgs.gov

USGS, Pasadena Field Office:
http://pasadena.wr.usgs.gov

Institutions in Alaska and the Pacific Northwest.

Univ. of Alaska, Geophysical Institute:
http://www.giseis.alaska.edu/Seis/

Oregon State University:
http://quakes.oce.orst.edu/Geophysics.html

University of Oregon -
http://darkwing.uoregon.edu/~dogsci/groups.html

Univ. of Washington, Deprt Earth & Space Sciences:
http://www.ess.washington.edu/SEIS/

West Coast & Alaska Tsunami Warning Center:
http://wcatwc.gov

Institutions in the inter-mountain US

Albuquerque Seismology Lab (USGS):
http://aslwww.cr.usgs.gov

Univ. of Arizona (SASO):
http://saso.geo.arizona.edu/saso/

Univ. of Colorado - Dept. of Physics (Geophysics Group):
http://tagg.colorado.edu/geophysics.html

Idaho National Engineering Lab (INEEL) Seismic Monitoring Program:
http://www.inel.gov/env-energyscience/seismic

Los Alamos Seismic Research Center, LANL, New Mexico
http://www.lasrc.lanl.gov

Montana Bureau of Mines Network - Earthquake information:
http://mbmgquake.mtech.edu/whats_shaking.html

New Mexico Tech - Geophysics Program:
http://www.ees.nmt.edu/Geop

Univ. of Nevada Reno:
http://www.seismo.unr.edu

US Bureau of Reclamation (WY, CO):
http://www.seismo.usbr.gov/seismo/eqinfo.html

Univ. of Utah (UUSS):
http://www.quake.utah.edu

Wyoming State Geological Survey - Geologic Hazards Section-
http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/quake.html

Institutions in the Eastern US

Harvard University Seismology:
http://www.seismology.harvard.edu

Indiana State Univ. "IndiSeis":
http://www.indstate.edu/gga/recent/index.html

IRIS Headquarters:
http://www.iris.edu

LCSN at LDEO Colombia U.:
http://www.ldeo.columbia.edu/LCSN

University of Memphis - Center for Earthquake Research and Information (CERI):
http://www.ceri.memphis.edu

Mid-America Earthquake Center:
http://mae.ce.uiuc.edu

Univ. of Michigan, "MichSeis":
http://www.geo.lsa.umich.edu/MichSeis

MIT Earth Resources Lab:
http://www-erl.mit.edu

OhioSeis, Ohio Seismic Network--Ohio Geological Survey
http://www.dnr.state.oh.us/OhioSeis

OhioSeis, College of Wooster, Ohio:
http://www.wooster.edu/seismic/seismic.html

Oklahoma Geological Survey:
http://www.okgeosurvey1.gov

Saint Louis University:
http://www.eas.slu.edu/Earthquake_Center

Princeton University:
http://geoweb.princeton.edu

Puerto Rico Seismic Network, University of Puerto Rico:
http://rmsismo.uprm.edu

Purdue University - Dept. of Earth and Atmospheric Sciences
http://http://www.eas.purdue.edu/

Univ. of South Carolina, "SCEPP":
http://www.seis.sc.edu

University of Tennessee (Eastern Tennessee Seismic Network):
http://tanasi.gg.utk.edu

University of Texas, Institute for Geophysics - Earthquake Studies:
http://www.ig.utexas.edu/research/overview/seismology.htm?PHPSESSID=cc081ec6f8ba0d9722ca9d697067347f

Virginia Tech Geological Sciences:
http://www.geol.vt.edu/outreach/vtso/

Washington University, Saint Louis, MO (Seismology):
http://levee.wustl.edu/seismology/seis.html

Weston Observatory of Boston College:
http://www.bc.edu/research/westonobservatory

Western Hemisphere Institutions (outside the US)

Argentina

Instituto Nacional de Prevencion Sismica (INPRES) http://www.inpres.gov.ar

Brazil

Observatorio Sismologico, Universidade de Brasilia

http://www.obsis.unb.br

Universidade de Sao Paulo, Brasil

http://www.iag.usp.br

Canada

Canadian National Earthquake Hazards Program:

http://www.seismo.nrcan.gc.ca

Cegep de Jonquiere, Quebec, Canada:

http://college.cjonquiere.qc.ca/sismo

Lithoprobe Seismic Processing Facility, Canada:

http://www.litho.ucalgary.ca/

Pacific Geoscience Centre - Western Canadian National Earthquake Hazards Program:

http://www.pgc.nrcan.gc.ca/seismo/table.htm

Université du Québec à Chicoutimi, TECHMAT station

http://sismo.uqac.uquebec.ca

Southern Ontario Seismic Network (SOSN):

http://www.gp.uwo.ca

Simon Fraser University, BC Canada - Custom earthquake map:

http://http://hoshi.cic.sfu.ca/quake.html

Caribbean

Seismic Research Unit - Trinidad West Indes

http://www.uwiseismic.com

Chile

Servicio Sismologico Nacional - Universidad de Chile:

http://ssn.dgf.uchile.cl

Colombia

OSSO - Observatorio Sismologico del Sur Occidente, Cali, Colombia

http://osso.univalle.edu.co

Costa Rica

Observatorio Vulcanologico y Sismologico de Costa Rica. OVSICORI-UNA:

http://www.una.ac.cr/ovsi

Laboratorio de Ingenieria Sismica, Universdad de Costa Rica

http://www2.fing.ucr.ac.cr/~lis/home.htm

Guatemala

INSIVUMEH, Guatemala City, Guatemala

http://www.insivumeh.gob.gt

El Salvador

Servicio Nacionales de Estudios Territoriales (SNET), San Salvador:

http://www.snet.gob.sv/Geologia/ultsent.php

Honduras

University of Honduras - Geophysics:

http://www.geofys.uu.se/~dca/geophysics.html

Mexico

Instituto de Geofisica, UNAM:

http://tlacaelel.igeofcu.unam.mx/

Servicio sismologico Natcional - Mexico

http://www.ssn.unam.mx

Nicaragua

Instituto Nicaraguense de Estudios Territoriales - Direccion de Geofisica:

http://www.ineter.gob.ni/geofisica/home-geofis.html

Panama

Instituto de Geociencias de la Universidad de Panama:

http://www.igc.up.ac.pa

Peru

Instituto Geofisico del Peru:

http://www.igp.gob.pe/

Venezuela

Laboratorio de Geofisica, Universidad de Los Andes, Venezuela

http://lgula.ciens.ula.ve

Fundacion Venezolana de Investigaciones Sismologicas (Funvisis), Venezuela

http://www.funvisis.org.ve

Regional Centers

Regional Center for Seismology for South America (CERESIS):

http://www.ceresis.org/new/index.htm

Centro Sismologico de America Central (CASC):

http://cariari.ucr.ac.cr/~web-casc/

Middle America Seismograph Consortium (MIDAS):

http://midas.upr.clu.edu

SALSA (Scientific ALliance for South America):

http://www.dgf.uchile.cl/salsa.html

Laboratorio de Geofmsica de la Universidad de Los Andes, Venezuela:

http://celeste.ciens.ula.ve

The University of the West Indies, Seismic Research Unit

http://www.uwiseismic.com/

European Institutions

A more complete list of European/Mediterranean area seismograph network operators can be found at:

http://orfeus.knmi.nl/other.services/network.shtml

European Strong-Motion Database

http://www.isesd.cv.ic.ac.uk

European Seismological Commission

http://www.esc.bgs.ac.uk

Austria

Zentralanstalt fur Meteorologie und Geodynamik, (Geophysik), Austria

http://www.zamg.ac.at

Osterreichischen Gesellschaft fur Erdbebeningenieurwesen und Baudynamik (OGE):

http://www.zamg.ac.at/~oge

Bulgaria

Bulgarian Academy of Sciences - Geophysical Institute:

http://www.geophys.bas.bg

Belgium

Royal Observatory of Belgium -Seismology:

http://www.oma.be/KSB-ORB/SEISMO

Czech Republic

Czech Geophysical Institute, Prague, Czech Republic:

http://www.ig.cas.cz

Charles University, Prague, Czech Republic:

http://geo.mff.cuni.cz/index_en.htm

Masaryk University Brno, Czech Republic:

http://www.ipe.muni.cz

Finland

University of Helsinki, Institute of Seismology

http://www.seismo.helsinki.fi

France

Centre Sismologique Euro-Mediterraneen/Euro-Mediterranean Seismological Centre (CSEM/EMSC):

http://www.emsc-csem.org

GEOSCOPE Data Center of IPGP:

http://geoscope.ipgp.jussieu.fr

Reseau SISMALP, Observatoire de Grenoble, France:

http://sismalp.obs.ujf-grenoble.fr/sismalpuk.html

Reseau Sismique Provence, Marseille, France:

http://jupiter.u-3mrs.fr/~ms422aww

Reseau National de Surveillance Sismique, France (ReNaSS):

http://renass.u-strasbg.fr

Tres Grande Resolution Sismologique, Universite de Nice, France (TGRS):

http://aster.unice.fr

Germany

Baden-Wuerttemberg Geological Survey, Erdbebendienst:

http://www.lgrb.uni-freiburg.de/lgrb/Fachbereiche/erdbebendienst

Bundesanstalt fur Geowissenschaften und Rohstoffe, Hanover (historical catalogs):

http://www.bgr.de/quakecat

Erdbebendienst Bayern, Germany:

http://www.erdbeben-in-bayern.de

GEOFON data center (Potsdam, Germany):

http://www.gfz-potsdam.de/geofon

Goethe-Universitat, Frankfurt; Institut fur Meteorologie und Geophysik:

http://www.geophysik.uni-frankfurt.de/geophys_en.html

German Earthquake Damage Analysis Center:

http://www.uni-weimar.de/Bauing/edac

Institut fur Geophysik (GERESS), Bochum, Germany

http://www.geophysik.ruhr-uni-bochum.de

Grafenberg Seismological Observatory (SZGRF):

http://www.szgrf.bgr.de

Seismic Data Analysis Center (SDAC), Bundesanstalt fur Geowissenschaften und Rohstoffe, Hannover, Germany

http://www-seismo.hannover.bgr.de

University of Munich - Department of Geophysics

http://www.geophysik.uni-muenchen.de

Geologische Dienst Nordrhein-Westfalen:

http://www.gd.nrw.de

Univ of Karlsruhe - Geophysical Institute:

http://www-gpi.physik.uni-karlsruhe.de/

Geol. Institut, Abteilung Erdbebengeologie, Universität zu Köln

http://www.seismo.uni-koeln.de

Institute of Geosciences, University of Potsdam:

http://www.uni-potsdam.de/u/Geowissenschaft/index.htm

Greece

Aristotle University of Thessaloniki (Geophysics), Greece
http://lemnos.geo.auth.gr

Athens University, Department of Geophysics-Geothermy
http://www.geophysics.geol.uoa.gr

Greek National Observatory of Athens - Geodynamic Institute:
http://www.gein.noa.gr

Institute of Engineering Seismology and Earthquake Engineering, Thessaloniki
http://www.itsak.gr

Univertiy of Patras - Laboratory of Seismology
http://seismo.geology.upatras.gr

Hungary

GeoRisk Ltd., Budapest (seismicity and earthquake hazards):
http://www.georisk.hu

Iceland

Icelandic Meteorolgical Office, Department of Geophysics:
http://hraun.vedur.is/ja/englishweb

Ireland

Dublin Institute for Advanced Studies Geophysics:
http://www.geophysics.dias.ie

Israel

The Geophysical Institute of Israel:
http://http://www.gii.co.il

Italy

Italian Experimental Seismic Network:
http://www.iesn.org

Laboratorio di Geofisica, Camerino University, Italy:
http://www.unicam.it/university/unitoper/geologia/LABGEOF.htm

The I.G.G. Seismic Network (Genoa University, Italy):
http://www.dipteris.unige.it/geofisica

Friuli Experimental Seismic Network, Venezia Giulia, Italy
http://www.fesn.org

Gruppo Nazionale per la Difesa dai Terremoti (GNDT of INGV):
http://gndt.ingv.it

Istituto Nazionale di Geofisica Vulcanologia, Italia (MedNet, Italian Telemetered Seismic Network, and other):
http://www.ingv.it

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Udine
http://www.crs.ogs.trieste.it

Istituto di Ricerca sul Rischio Sismico, Milano e Istituto per le Tecnologie Informatiche Multimediali, Milano:
http://emidius.itim.mi.cnr.it/DOM/

INGV Sezione di Milano - directory index
http://emidius.mi.ingv.it

Servizio Sismico Nazionale, Italia (National Seismic Service of Italy):
http://www.serviziosismico.it

Universita di Trieste, Italia (Dipartimento di Scienze della Terra):
http://www.dst.univ.trieste.it/seismology.html

International Centre for Theoretical Physics, Trieste, Italy (Structure and non-linear dynamics of the earth group):
http://www.ictp.trieste.it/sand

Osservatorio Geofisico Sperimentale di Macerata, Italy:
http://www.geofisico.it

Sistema Poseidon - Sicilia orientale, Italy http://www.poseidon.nti.it

Osservatorio Vesuviano, Napoli, Italy

http://www.ov.ingv.it/seismology/sss_main.htm

The Netherlands

Network of Autonomously Recording Seismographs - NARS, Utrecht University, The Netherlands

http://www.geo.uu.nl/~nars

ORFEUS Data Center (Royal Netherlands Meteorological Institute - KNMI):

http://orfeus.knmi.nl

Norway

Institute of Solid Earth Physics, University of Bergen

http://www.ifjf.uib.no/Seismologi/index.html

NORSAR (Research Council of Norway):

http://www.norsar.no

Poland

Polish Academy of Sciences of Institute of Geophysics, Warszawa, Poland:

http://wwwseis.igf.edu.pl

Portugal

Instituto Geofisico do Infante D. Luis, Portugal

http://www.igidl.ul.pt

Instituto de Meteorologia, Portugal

http://www.meteo.pt/sismologia/sismologia.html

Romania

Romania National Institute for Earth Physics (RONIEP):

http://www.infp.ro

Russia

Kola Regional Seismological Center (KRSC), Russian Academy of Science

http://www.krsc.ksc.ru/krsc

Moscow IRIS Data Analysis Center (MDC):

http://synapse.ru/eng/

Russian Academy of Sciences. Planetary Geophysics. Moscow, Russia:

http://www.wdcb.rssi.ru

Russian Academy of Sciences. Geophysical Survey. Obninsk -

http://www.gsras.ru

Slovenia

Geophysical Survey of Slovenia:

http://www.sigov.si/ugf/ang/gf.html

Spain

Instituto Andaluz de Geofisica, Spain

http://www.ugr.es/iag/iagpds.html

Institut Cartografic de Catalunya, Barcelona:

http://www.icc.es/sismes/home.html

Instituto de Ciencias de la Tierra 'Jaume Almera', Barcelona:

http://dg.ija.csic.es

Instituto Geografico Nacional (IGN) - Madrid, Spain:

http://www.geo.ign.es

Switzerland

Swiss Seismological Service, ETH Zurich (Europe and world-wide catalogs and maps):

http://www.seismo.ethz.ch

Turkey

Kandilli Observatory and Earthquake Research Institute (Turkey):

http://www.koeri.boun.edu.tr

Special Kocaeli (Izmit) Earthquake Pages:

http://geophysics.gg.utk.edu/izmit/earthquake.htm (mirror of Turkish site)

Ministry of Public Works and Settlement, Earthquake Research Department, Republic of Turkey:

http://www.deprem.gov.tr

Tubitak MRC Earth Sciences Research Institute:

http://www.nemrut.mam.gov.tr

United Kingdom

U of Bristol Earthquake Engineering Research Centre:

http://www.cen.bris.ac.uk/research/eerc/index.html

British Geological Survey, Global Seismology Research Group:

www.earthquakes.bgs.ac.uk

Edinburgh, Scotland:

http://www.geo.ed.ac.uk/quakes/quakes.html

Department of Earth Sciences: Seismology. University of Oxford:

http://www.earth.ox.ac.uk/research/seismology.htm

Yugoslavia

Montenegro Seismological Observatory, Podgorica, Yugoslavia:

http://www.seismo.cg.yu

Institutions in Africa, Asia and Oceania

Algeria

Departement Etudes et Surveillance Sismique, Algeria

http://www.craag.edu.dz/ess/index.htm

South Asia

Amateur Seismic Center for south Asia:

http://www.asc-india.org

Southeast Asia

ASEAN Earthquake Information Center (AEIC):

http://aeic.bmg.go.id

Australia

Australian National University, (RSES Seismology):

http://rses.anu.edu.au/seismology/seismology.html

Geoscience Australia (formerly: Australian Geological Survey):

http://www.ga.gov.au

University Of Queensland Advanced Centre for Earthquake Studies:

http://quakes.earth.uq.edu.au/

Seismology Research Centre, Melbourne:

http://www.seis.com.au

China

China Earthquake Administration:

http://www.icce.ac.cn/icce/cea (in English),
and http://www.cea.gov.cn (in Chinese)

China Seismograph Network Data Management Center (CSNDMC):

http://www.csndmc.ac.cn

China Digital Seismograph Network (CDSN):

http://www.cdsn.org.cn (in Chinese)

Seismological Society of China (SSC):

http://www.ssoc.org.cn

Hong Kong Observatory
http://www.weather.gov.hk/gts/equake/seismic_mon_e.htm

India

India Meteorological Department
http://www.imd.ernet.in/section/seismo/dynamic

Iran

International Institute of Earthquake Engineering and Seismology, Iran
http://www.iiees.ac.ir/English/eng_index.html

Japan

Earthquake Research Institute at the University of Tokyo:
http://www.eri.u-tokyo.ac.jp

Geological Survey of Japan - Earthquake Research:
http://www.aist.go.jp/GSJ/pEQ/eq_top.htm

Kyoshin Net (K-NET) - Japan strong-motion data center of NRI for Earth Science and Disaster Prevention
http://www.k-net.bosai.go.jp/

Fundamental Research on Earthquakes and Earth'S Interior Anomalies- (Freesia) of NIED, Japan - broad-band network:
http://www.fnet.bosai.go.jp

National Research Institute for Earth Science and Disaster Prevention (NIED), Japan - home page:
http://www.bosai.go.jp/center/

Korea

Korea Meteorological Administration
http://www.kma.go.kr/kmas/kma/english/main.html

Malaysia

Malaysian Meteorological Service, Seismological Services-
http://www.kjc.gov.my

Morocco

Institut Scientifique, Rabat, Morocco (Dipartement de Physique du Globe):
http://www.israbat.ac.ma/acceuil.htm

Nepal

Nepal National Seismological Center
http://seismonepal.gov.np

New Zealand

Victoria University, Institute of Geophysics, New Zealand
http://www.geo.vuw.ac.nz/gphs/index.html

Institute of Geological and Nuclear Sciences:
http://www.gns.cri.nz/earthact/earthquakes

Pakistan

Pakistan Meteorological Department (Geophysics):
http://met.gov.pk/Subpage4/geophysics_page.html

Philippines

Philippine Institute of Volcanology and Seismology
http://www.phivolcs.dost.gov.ph

South Africa

Geological Survey of South Africa, Seismic Research Unit
http://www.geoscience.org.za/seismo

Taiwan

Broadband Array in Taiwan for Seismology (BATS):
http://bats.earth.sinica.edu.tw

Central Weather Bureau - Taiwan Seismic Information,
http://www.cwb.gov.tw/V4e/index.htm

Seismic information relating to volcanic activity.

Alaska Volcano Observatory (AVO):
http://www.avo.alaska.edu

Cascades Volcano Observatory (CVO):
http://vulcan.wr.usgs.gov/home.html

Mount Erebus Volcanic Observatory (New Mexico Tech):
http://www.ees.nmt.edu/Geop/erebus.html

Hawaiian Volcano Observatory (USGS/HVO):
http://hvo.wr.usgs.gov/

USGS Volcano Hazards Program - Long Valley Caldera:
http://quake.wr.usgs.gov/VOLCANOES/LongValley/index.html

Yellowstone Caldera seismicity - Univ. of Utah:
http://www.seis.utah.edu/HTML/YPSeismicityMaps.html

Links to more general Volcanology information.

Michigan Technological University Volcanoes Page:
http://www.geo.mtu.edu/volcanoes/other.html

Jonathan Dehn's "The Volcanic Homepage" (most complete listings found):
http://www.v-home.alaska.edu/

Smithsonian Institution - Global Volcanism Program:
http://www.volcano.si.edu/gvp

US Geological Survey general volcano pages:
http://volcanoes.usgs.gov

Volcanosurfing pages by Hugues Dufumier:
http://eost.u-strasbg.fr/~hugues/subvolcano.html

Other useful references

American Geophysical Union:
http://earth.agu.org/homepage.html

Earthquake Engineering Research Institute (EERI):
http://www.eeri.org

EQnet - General earthquake information index
http://www.eqnet.org

European Geosciences Union
http://www.copernicus.org/EGU/index.html

European Seismological Commission:
http://www.gsrg.nmh.ac.uk/esc

Seismological Society of America
http://www.seismosoc.org

Cascade Region Earthquake Workgroup (CREW) - public-private coalition
http://www.crew.org

Central United States Earthquake Consortium
http://www.cusec.org

Geological Society of America
http://www.geosociety.org/index.htm

Western States Seismic Policy Council (WSSPC):
http://www.wsspc.org

Seismolinks to a comprehensive list of general seismological resources:

http://pasadena.wr.usgs.gov/seismolinks.html

General Tsunami information and resources - C.E. University of Washington:

http://www.ess.washington.edu/tsunami/intro.html

Instructions for obtaining seismic data without a WEB browser.

Finger USAGE:

Ftp USAGE:

`ftp machine.domain' ; login: anonymous ; password: e-mail_address

E-mail USAGE:

mail autodrm@machine.domain ; include text: `PLEASE HELP'. Detailed instructions will be e-mailed back to you.

Bulletin Board USAGE:

`telnet (or rlogin) machine.domain' ; login: special name and password.

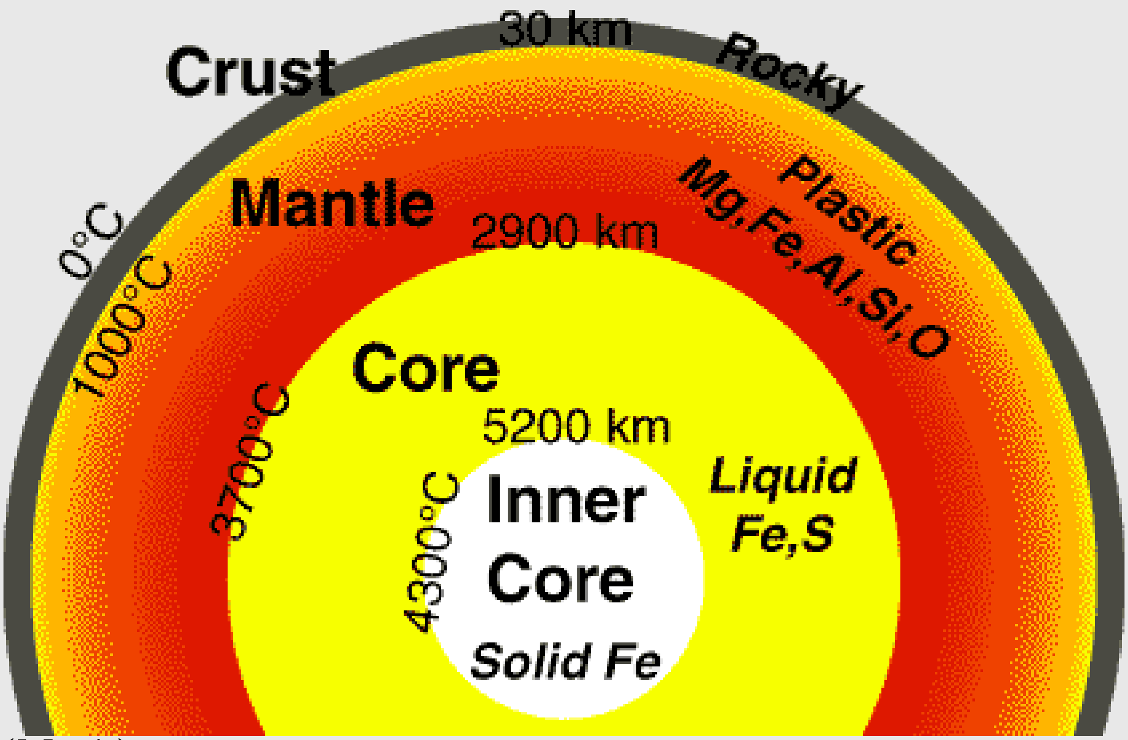
Referenced by the NSF sponsored UniGuide Academic Guide to the Internet.

This is file /seismosurfingbig.html, last modified 6/25/02

Earth's Interior

More about earthquakes | Nevada Seismological Lab | Nevada earthquakes | Univ. of Nevada, Reno

Five billion years ago the Earth was formed in a massive conglomeration and bombardment of **meteorites** and **comets**. The immense amount of heat energy released by the high-velocity bombardment melted the entire planet, and it is still cooling off today. Denser materials like iron (Fe) from the meteroites sank into the core of the Earth, while lighter **silicates** (Si), other oxygen (O) compounds, and water from comets rose near the surface.



(J. Louie)

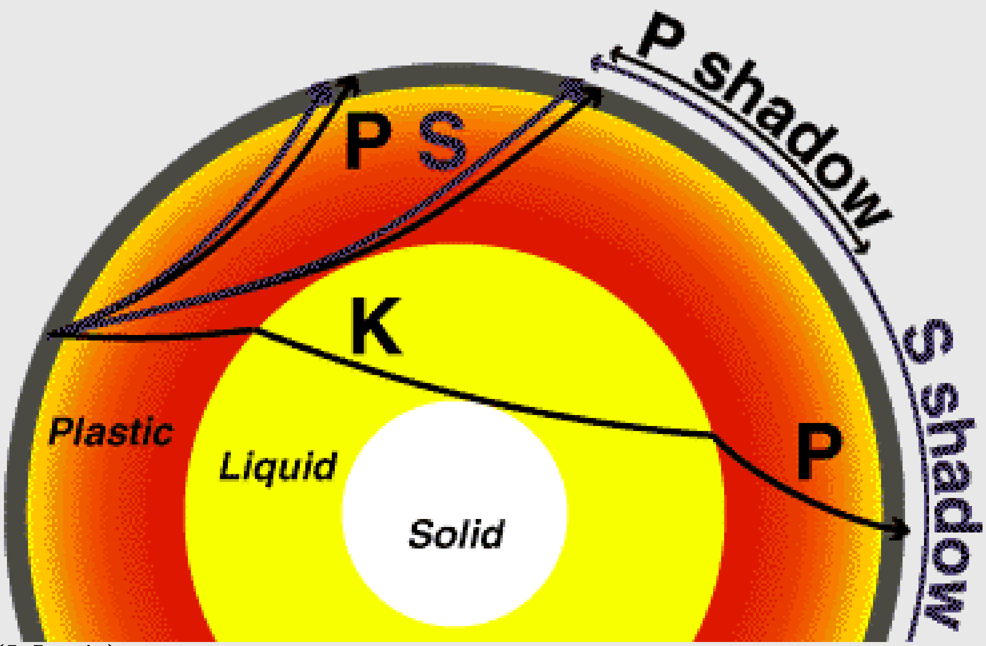
The earth is divided into four main layers: the **inner core, outer core, mantle**, and **crust**. The core is composed mostly of iron (Fe) and is so hot that the outer core is **molten**, with about 10% sulphur (S). The inner core is under such extreme **pressure** that it remains solid. Most of the Earth's mass is in the mantle, which is composed of iron (Fe), magnesium (Mg), aluminum (Al), silicon (Si), and oxygen (O) **silicate** compounds. At over 1000 degrees C, the mantle is solid but can deform slowly in a **plastic** manner. The crust is much thinner than any of the other layers, and is composed of the least dense calcium (Ca) and sodium (Na) aluminum-silicate minerals. Being relatively cold, the crust is rocky and **brittle**, so it can fracture in **earthquakes**.

Exploring the Earth's Core

How was the Earth's core dicovered? Recordings of seismic waves from earthquakes gave the first clue. Seismic waves will bend and reflect at the interfaces between different materials, just like the prism below **refracts** and scatters light waves at its faces.

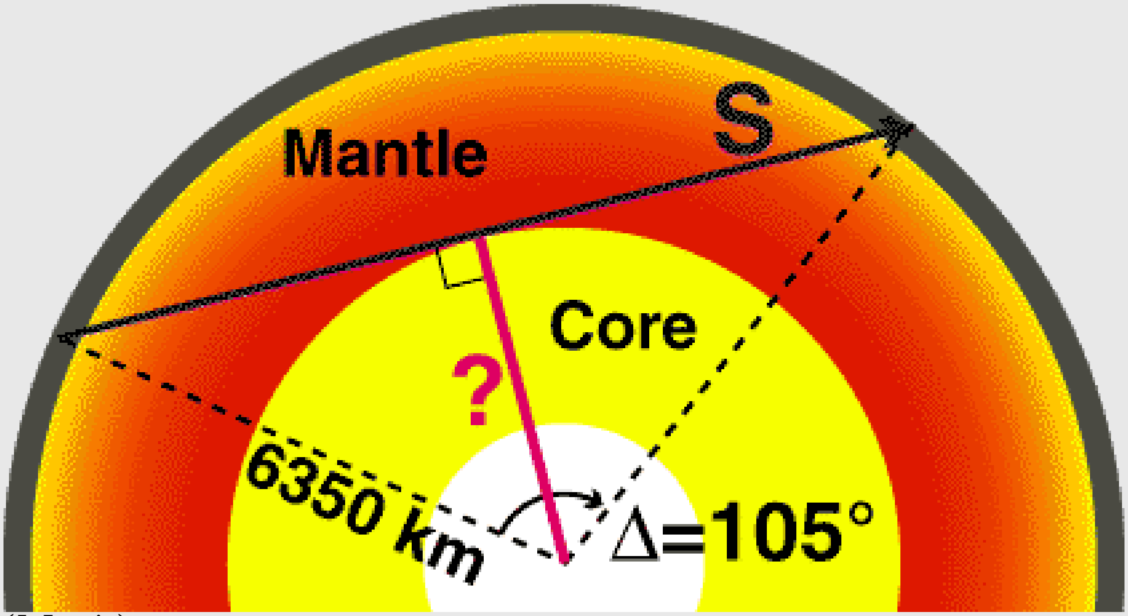
(original image from the Exploratorium; used by permission)

In addition, the two types of seismic wave behave differently, depending on the material. Compressional **P waves** will travel and refract through both **fluid** and solid materials. Shear **S waves**, however, cannot travel through fluids like air or water. Fluids cannot support the side-to-side particle motion that makes S waves.



(J. Louie)

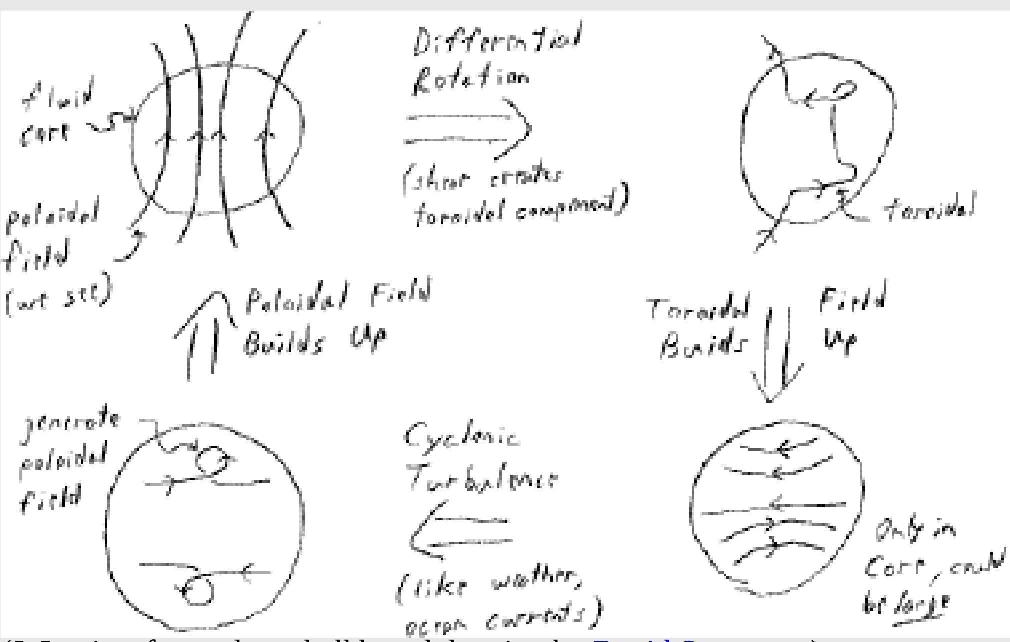
Seismologists noticed that records from an earthquake made around the world changed radically once the event was more than a certain distance away, about 105 degrees in terms of the angle between the earthquake and the seismograph at the center of the earth. After 105 degrees the waves disappeared almost completely, at least until the slow **surface waves** would arrive from over the horizon. The area beyond 105 degrees distance forms a **shadow zone**. At larger distances, some P waves would arrive, but still no S waves. The Earth has to have a molten, fluid core to explain the lack of S waves in the shadow zone, and the bending of P waves to form their shadow zone.



(J. Louie)

You can get a rough estimate of the size of the Earth's core by simply assuming that the last S wave, before the shadow zone starts at 105 degrees, travels in a straight line. Knowing that the Earth has a radius of about 6350 km, you have a right triangle where the cosine of half of 105 degrees equals the radius of the core divided by the radius of the earth.

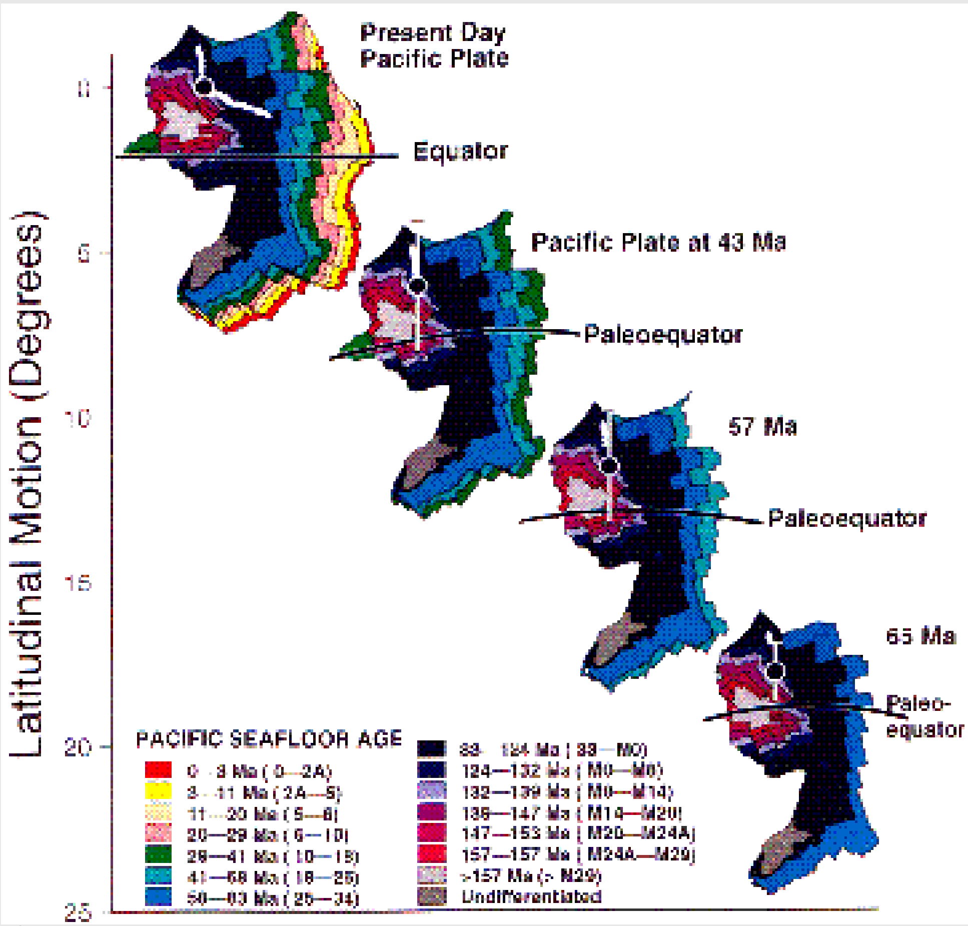
The fact that the Earth has a **magnetic field** is an idependent piece of evidence for a molten, liquid core. A compass magnet aligns with the magnetic field anywhere on the Earth, but other bodies like the Moon and Mars have no magnetic field. The earth cannot be a large **permanent magnet**, since magnetic minerals lose their magnetism when they are hotter than about 500 degrees C. Almost all of the earth is hotter, and the only other way to make a magnetic field is with a circulating **electric current**. Circulation and **convection** of **electrically conductive** molten iron in the Earth's outer core produces the magnetic field. To make the magnetic field, the convection must be relatively rapid (much faster than it is in the plastic mantle), so the core must be fluid.



(J. Louie, after a class chalkboard drawing by David Stevenson)

Because the Earth's magnetic field arises in the unstable patterns of fluid flow in the core, it changes direction at irregular intervals. In recent geologic history it may have switched direction about every 20,000 years. Any kind of geologic deposit (e.g.: lava flows, layered muds) put down over time will thus have different layers magnetized in opposing directions, recording the magnetic field direction as it was when the layer solidified. Geophysicists can measure the changes in direction to make a **magnetostratigraphy** for the deposit.

At oceanic **spreading centers** new ocean floor is being created constantly and slowly moved away from the rift. The farther the rock is from the rift, the older it is, and it will also show the **magnetic reversals** like a tape recording.

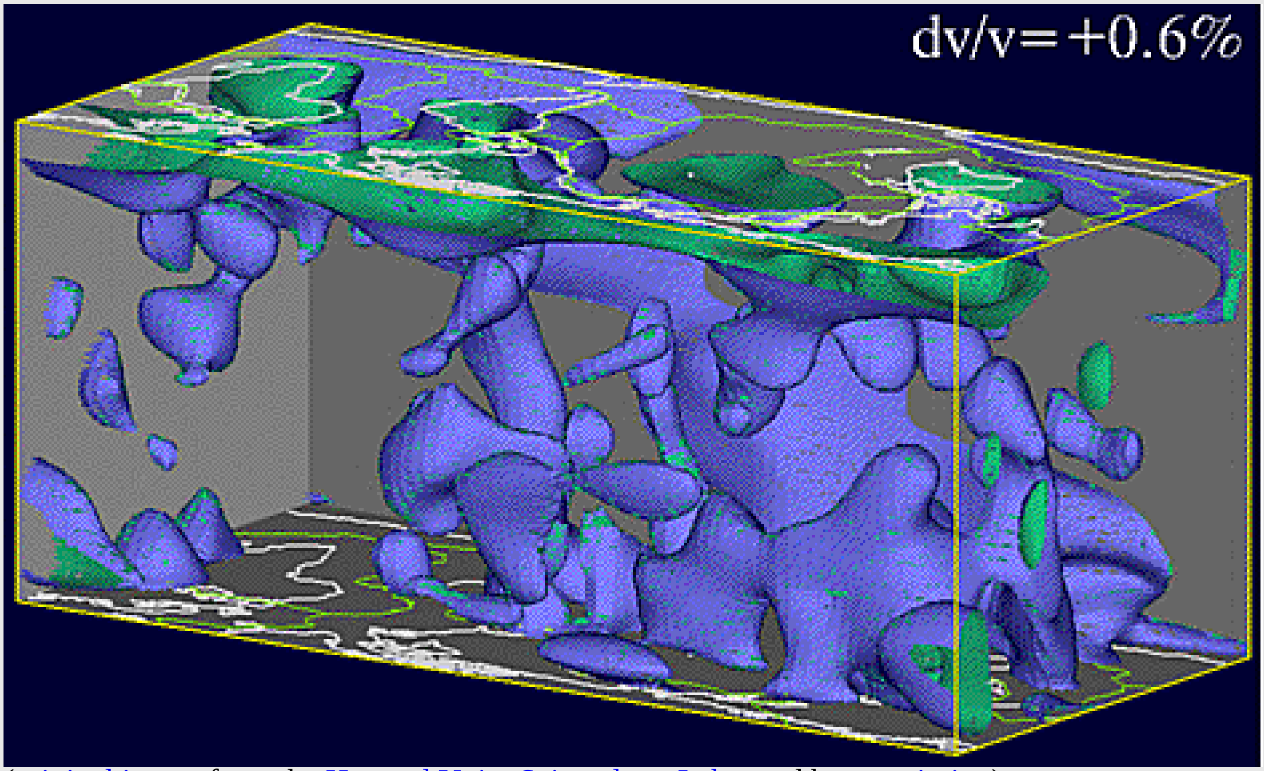


(from [Acton and Petronotis, *EOS*, 1994]; [Amer. Geophys. Union])

This map of the **Pacific Plate** at various stages of geologic history could be constructed from the tape recording. Such maps show how the [tectonic plates] have re-arranged themselves over the last 200 million years.

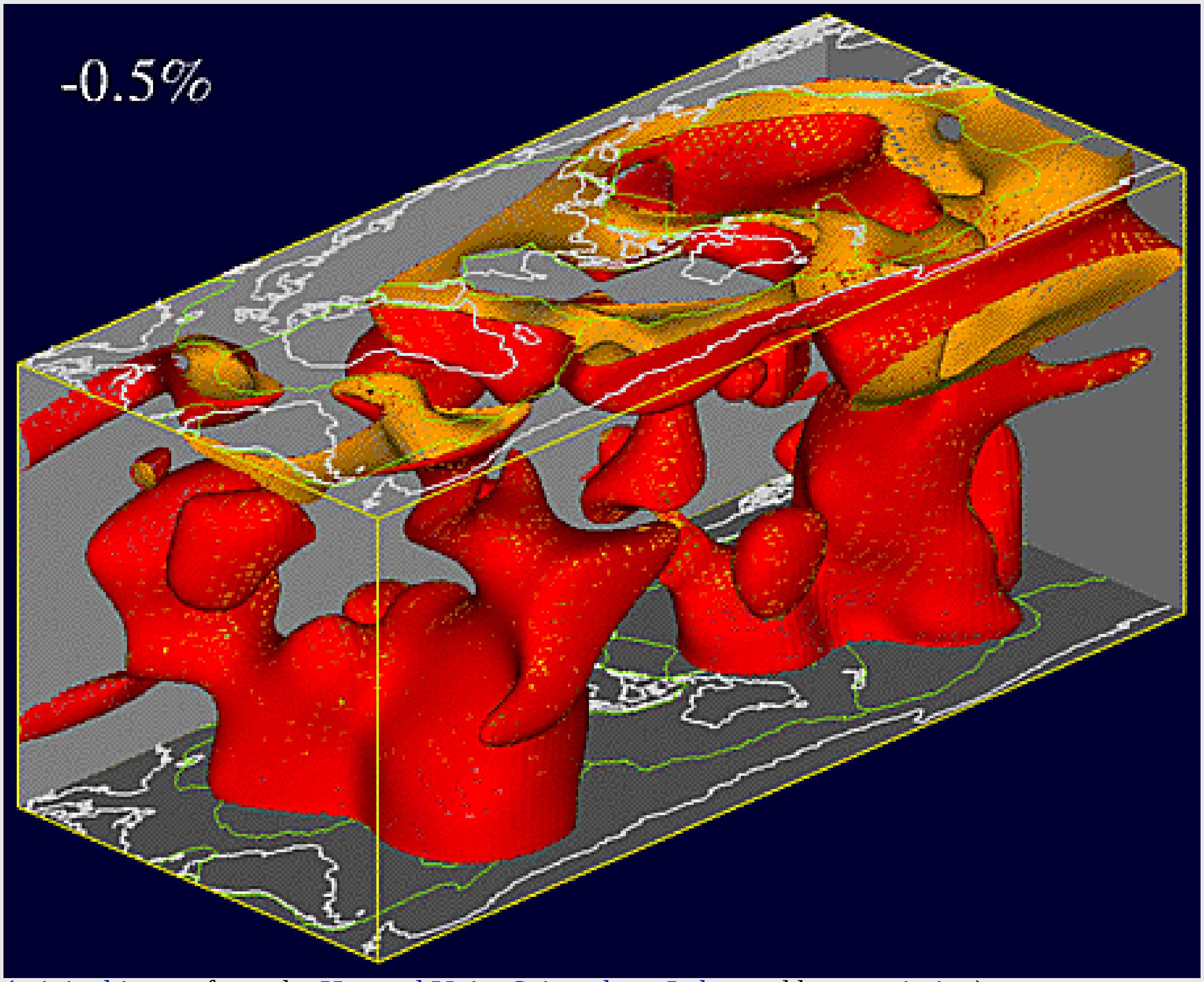
Exploring the Earth's Mantle

Convection and the release of heat from the Earth's core drives further convection to release heat from the mantle. Convection in the mantle drives [plate tectonic] motions of the sea floor and continents. It is possible to use P waves and S waves traveling through the mantle from earthquakes to map out this convection, much like a hospital CAT scan can map out bones and organs with x-rays.



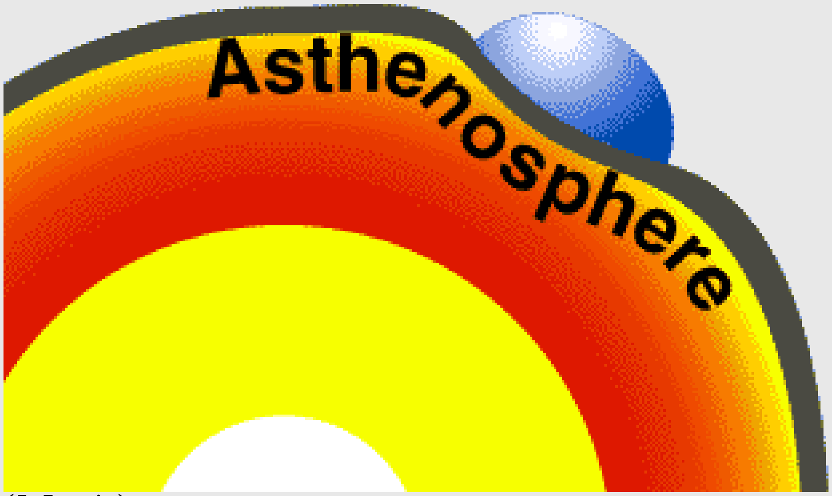
(original image from the Harvard Univ. Seismology Lab; used by permission)

In this view of a flattened-out mantle from the northwest, the blue blobs show where colder, denser material is sinking into the mantle. Near the surface, most of the colder material is in the ancient roots of continental **cratons**. **Subducting slabs** of oceanic **lithosphere** also appear, being recycled into the mantle from oceanic **trenches**.



(original image from the Harvard Univ. Seismology Lab; used by permission)

In this view from the southwest the red blobs are warmer plumes of less dense material, rising principally into the ocean-ridge spreading centers. A huge plume seems to be feeding spreading at the East Pacific Rise directly from the core. Most of the heat being released from the earth's interior emerges at the fast-spreading East Pacific Rise.

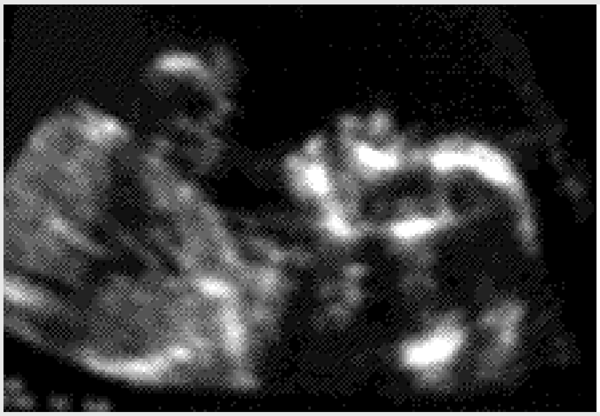
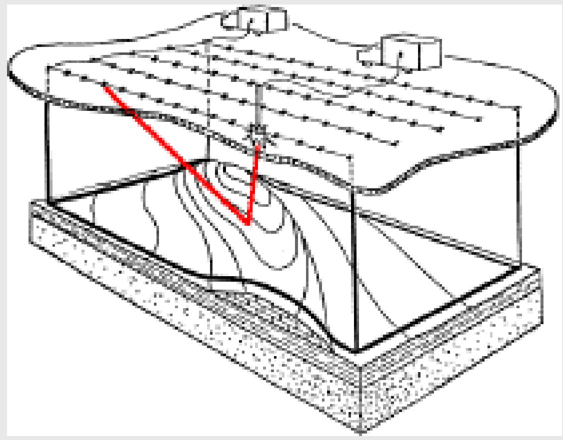


(J. Louie)

The part of the mantle near the crust, about 50-100 km down, is especially soft and plastic, and is called the **asthenosphere**. The mantle and crust above are cool enough to be tough and elastic, and are known as the **lithosphere**. A heavy load on the crust, like an **ice cap**, large glacial lake, or mountain range, can bend the lithosphere down into the asthenosphere, which can flow out of the way. The load will sink until it is supported by **buoyancy**. If an ice cap melts or lake dries up due to climatic changes, or a mountain range erodes away, the lithosphere will buoyantly rise back up over thousands of years. This is the process of **isostatic rebound**.

Exploring the Earth's Crust

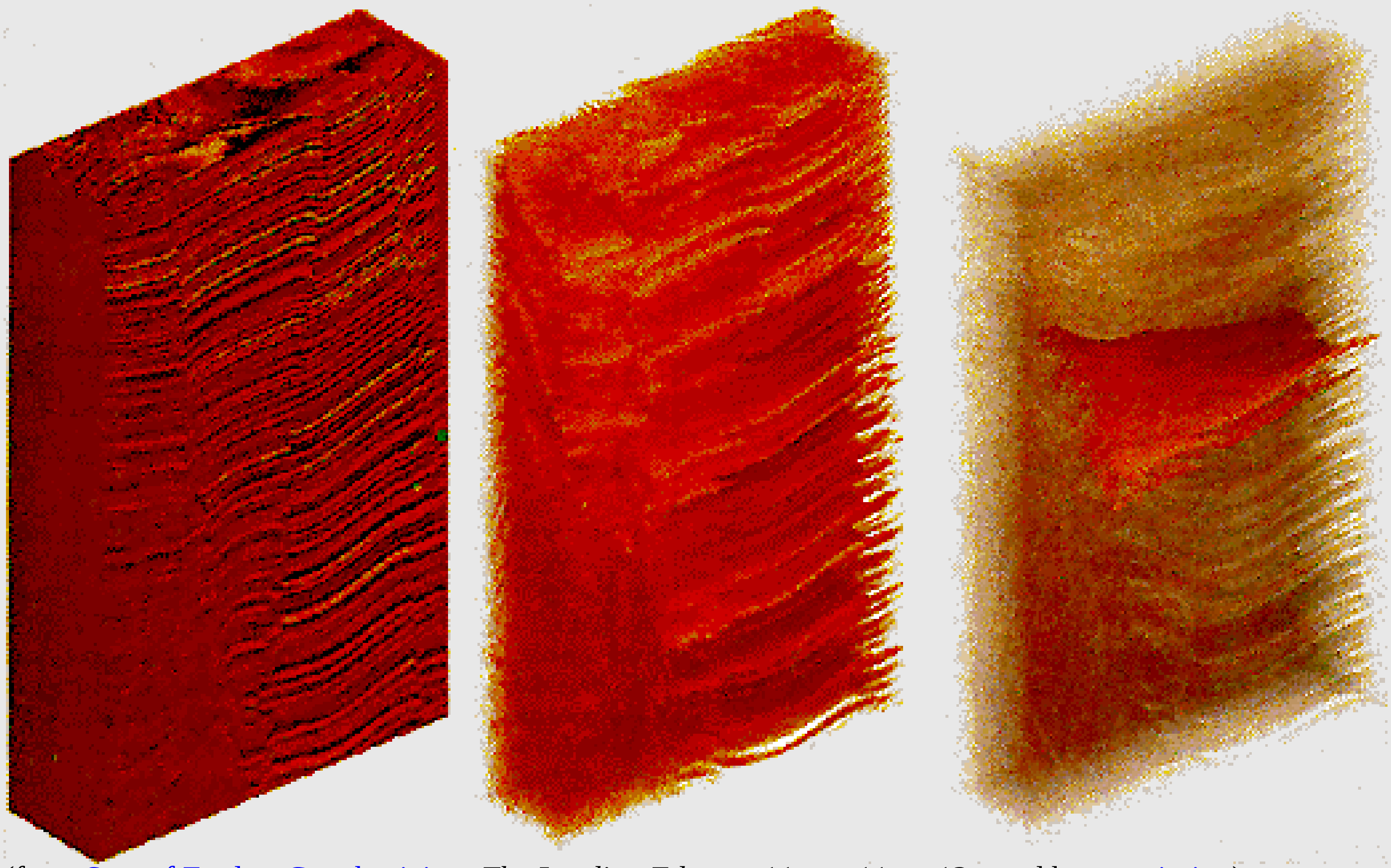
The nearby crust of the Earth can be explored in great detail with echo-sounding techniques, a kind of acoustic radar. These methods give images in cross section very similar to hospital **sonograms**:

(J. Louie; M. Hewitt, Soc. of Explor. Geophysicists)

A sonogram in the crust is called a **seismic reflection** section. Seismic waves from small explosions or thumper trucks send back echoes from rock layers many kilometers down that arrays of **seismograph** instruments can pick up.

Seismic reflection sections can show blocks of the crust in great detail. Individual layers can be studied for their potential to hold oil, gas, or water; to conduct contaminants from a dump site; or to describe their geologic origin and history.

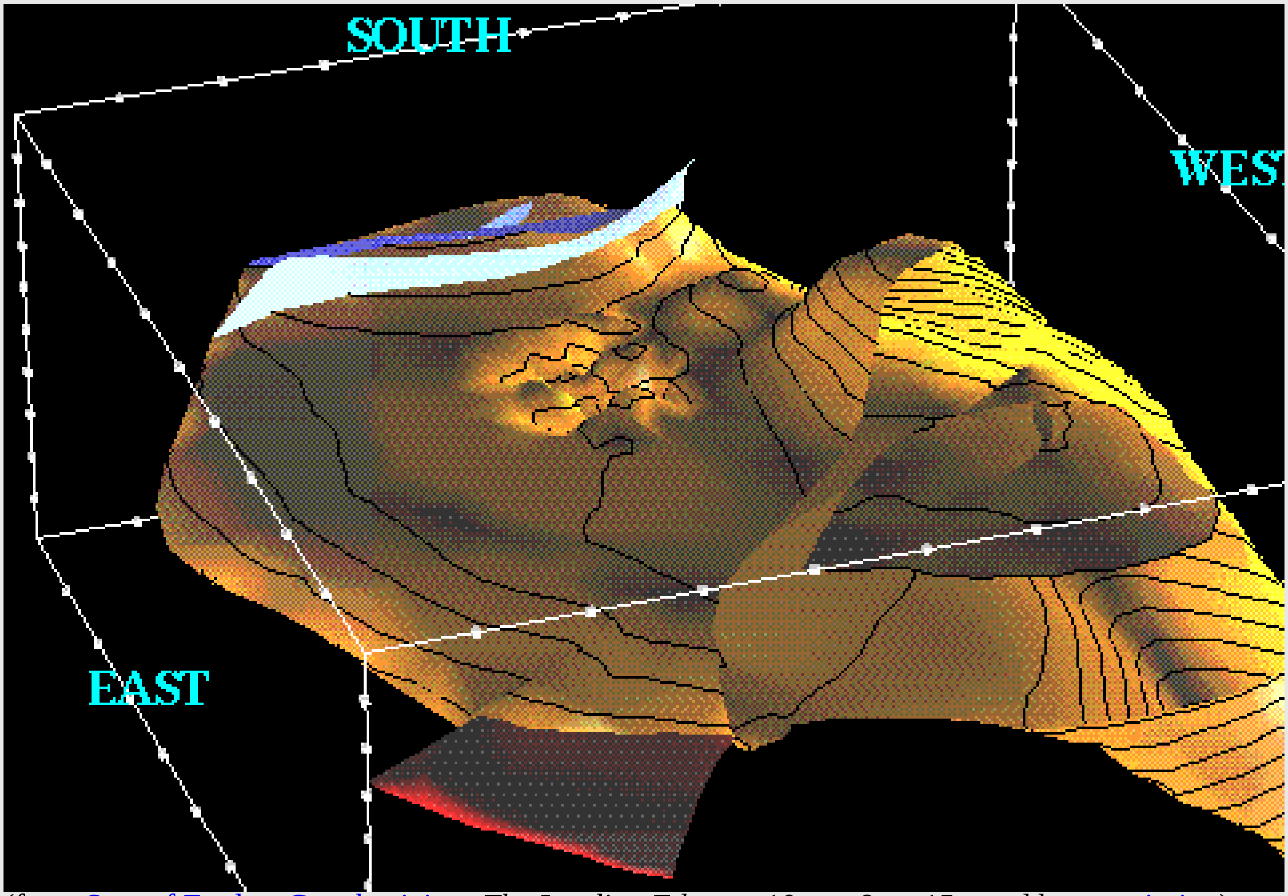


(from Soc. of Explor. Geophysicists, *The Leading Edge*, *v. 11*, no. 11, p. 13; used by permission)

This study of one layer maps out an ancient network of sandy **stream channels**, much like the modern channels of the Laramie River, right. Such buried channels can yield oil or gas easily if seismic reflection work can pinpoint their locations.

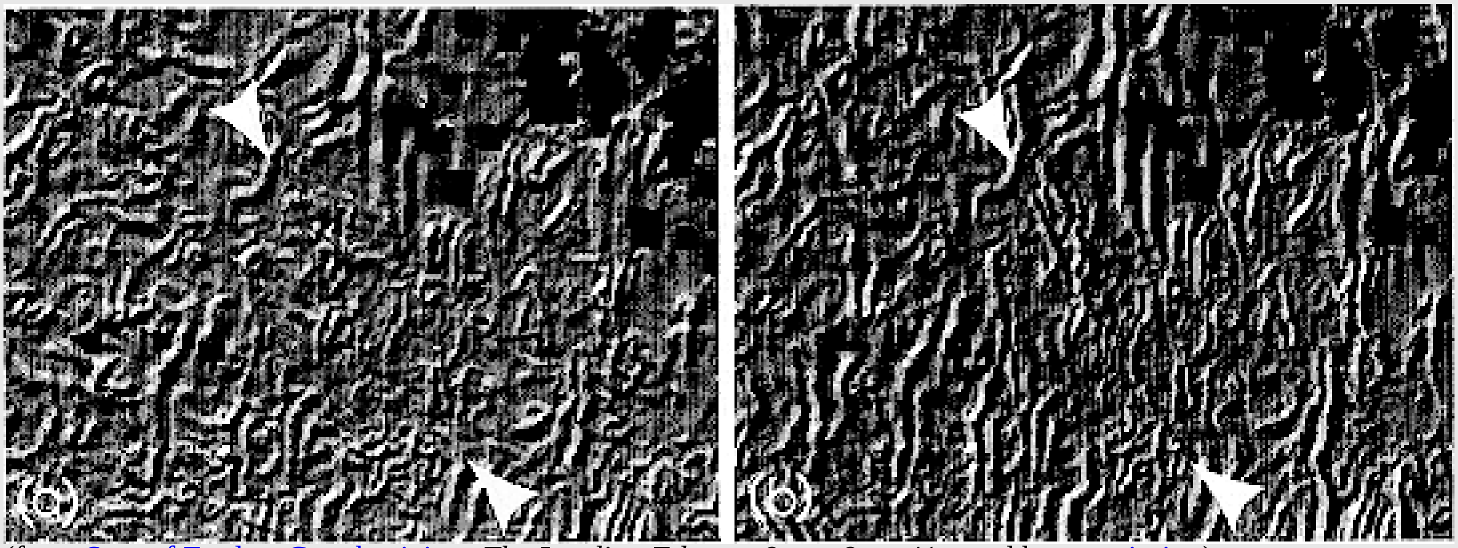
(from Soc. of Explor. Geophysicists, *The Leading Edge, v. 12*, no. 6, p. 683; *v. 11*, no. 8, p. 13; used by permission)

Development geophysicists can build detailed models of complex structures having many different formations deformed by all types of faults and folds. With these details they can plan the extraction of oil, gas, coal, or other minerals. They can also predict how **ground water** may flow through an area, and find the most efficient strategies to clean up contamination.



(from Soc. of Explor. Geophysicists, *The Leading Edge, v. 10*, no. 8, p. 15; used by permission)

Geophysicists can also make maps of other physical properties that rocks show over an area. **Gravitational pull, magnetic field strength, electrical conductivity, radioactivity**, and **spectral reflectance** are all properties that may be used to detect particular rock formations of economic or geologic interest, even if they are buried below the surface.

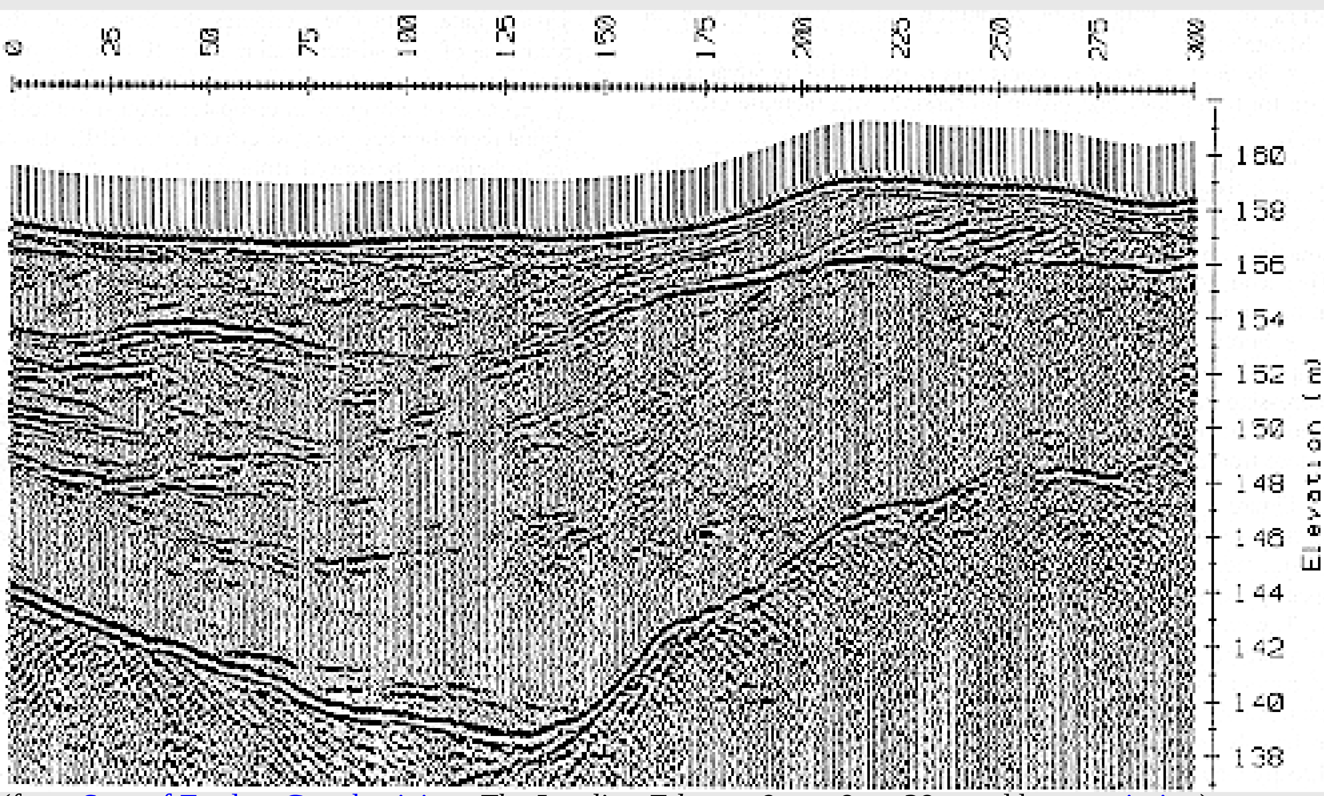


(from [Soc. of Explor. Geophysicists](), *The Leading Edge, v. 9*, no. 9, p. 41; used by [permission]())

The maps above are derived from maps of magnetic field strength in a part of Nevada. Computerized artificial illumination from the right direction reveals a subtle **lineament** in the image. A buried, slightly magnetized **dike** could contain gold ores.

Engineering and Environmental Assessments

Very high-resolution geophysical methods can help geologists wishing to make detailed environmental or engineering studies of rock masses near the surface. Such seismic reflection studies require sources of waves no more powerful than a hammer blow.



(from [Soc. of Explor. Geophysicists](), *The Leading Edge, v. 9*, no. 9, p. 39; used by [permission]())

The image above is the output of a **ground-probing radar**, which is very good at locating buried pipes, cavities, fractures, and metallic objects. Here it reveals the detailed structure of a soil layer only 20 m thick, showing channels likely to collect contaminated ground water.

J. Louie, 10 Oct. 1996

Previous: Earthquake Intensity

More about earthquakes | Nevada Seismological Lab | Nevada earthquakes | Univ. of Nevada, Reno

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Earthquake Effects

The effects of any earthquake depend on a number of widely varying factors. These factors are all of:

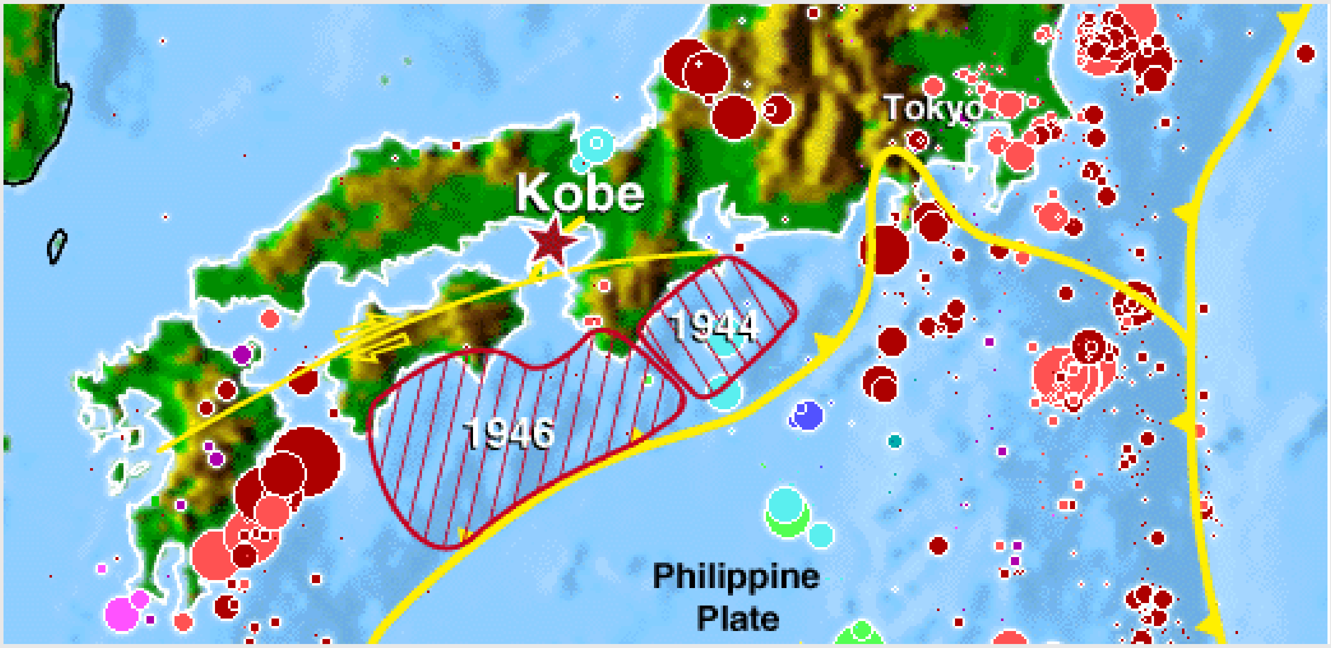
- **Intrinsic** to the earthquake - its magnitude, type, location, or depth;
- **Geologic** conditions where effects are felt - distance from the event, path of the seismic waves, types of soil, water saturation of soil; and
- **Societal** conditions reacting to the earthquake - quality of construction, preparedness of populace, or time of day (e.g.: rush hour).

One can count the number of deaths caused by large earthquakes to compare the results of all these disparate factors in combination. The Oct. 17, 1989 **Loma Prieta** earthquake occurred in the least-populated area of the generally urban San Francisco peninsula. Construction standards in the area are relatively high, and the populace relatively prepared. However, soft, highly-saturated soils near San Francisco Bay caused some spectacular failures of large highway structures unusually far away from the event. Even though it was rush hour, many fewer cars were on the roads due to the start of the opening game of the World Series, being played locally. Thus deaths were limited to about 75.

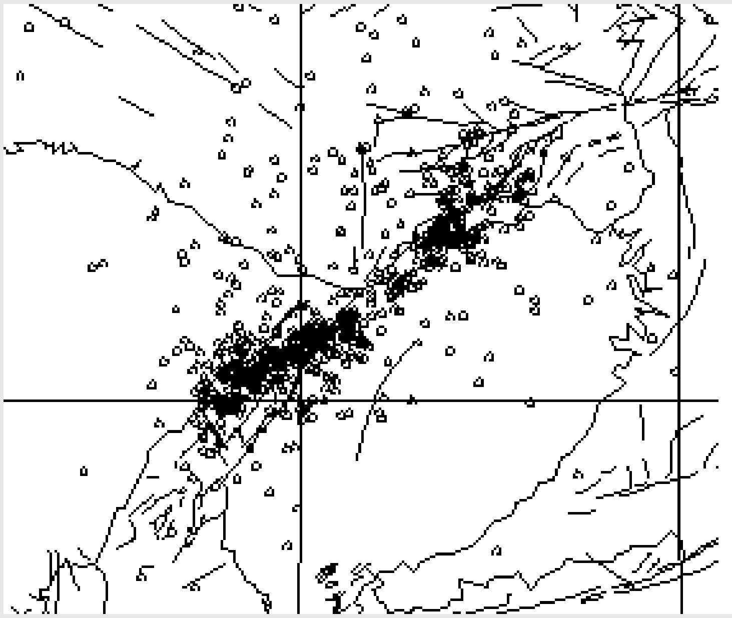
On the other hand, the same year an earthquake of nearly identical energy struck the war-torn country of **Armenia**, between Russia and Turkey. It was located much closer to the major cities of the region, where poorly-engineered houses of unreinforced concrete collapsed on their occupants during the night. The number of fatalities passed 25,000.

Jan. 17, 1995 Hyogo-Ken Nanbu Earthquake

The worst earthquake catastrophe in years occurred on western Honshu Island early this year. More than 5000 people perished in southern Hyogo prefecture, most in the city of Kobe, Japan's most important port. The loss of so many lives, in a country where so much effort had been made to prepare for earthquakes, shocked observers worldwide. However, the magnitude of this catastrophe is probably due to a terrible coincidence of a few simple seismological and societal factors, which may become clear in the photos below.



(from the USGS) Kobe is located farther than many other cities in Japan from the dangerous intersection of three tectonic plates: the Pacific, Eurasian, and Philippine. This **triple junction** is a junction of three compressive **subduction zones**. The red-hatched areas above are the parts of the subduction fault that had aleady broken in great earthquakes in 1944 and 1946. Kobe is also somewhat off the **Median Tectonic Line**, a zone of **strike-slip** faults.



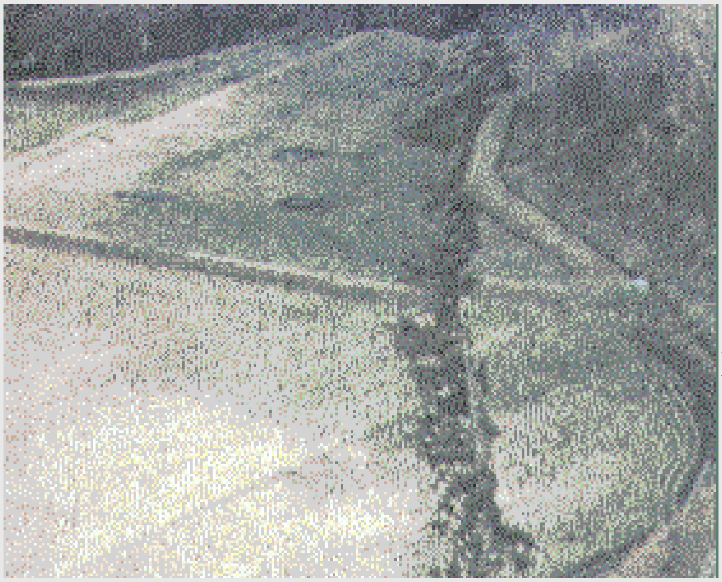
(from the Earthquake Research Institute, Tokyo) This map shows the **epicenters** of the earthquake's **aftershocks** within the first two days afterward. Decades of observation show that the most reliable way to locate the fault that broke in any earthquake is to observe where aftershocks are concentrated. This map shows that the earthquake fault obliquely cut the north side of Awaji Island, and cossed the bay to run along the Honshu coast directly below the city of Kobe. Probably the most important coincidence leading to the mass casualties was this ``direct hit" of the city by such a large faulting event. There was no intervening distance to mitigate the effects. The **Northridge** area of Los Angeles suffered a similar coincidence in January 17, 1994.

Direct Effects

There are two classes of earthquake effects: **direct**, and **secondary**. Direct effects are solely those related to the deformation of the ground near the earthquake fault itself. Thus direct effects are limited to the area of the exposed fault **rupture**. Many earthquake faults (such as at Northridge) never break the surface, ruling out direct effects. In the Hyogo-Ken Nanbu event, surface rupture of the fault was observed only in a rural area of Awaji Island, with displacements of up to 3 meters. Few structures were near enough the fault to be damaged by the displacement, although underground utilities, fences, and irrigation ditches were cut. Rice paddies were thrown far out of level.

(taken by the Geographical Survey Institute of Japan; used by permission.)

Aerial view of the fault rupture on northern Awaji Island, taken on January 18th, the day after the event. From left to right along the rupture, a **landslide** from the rupture covers a road; a fault **scarp** across a rice paddy; a **right-lateral** offset in a dirt road (inset); and three more pointers to the scarp. Note how little damage there apparently is to homes even very close to the fault.

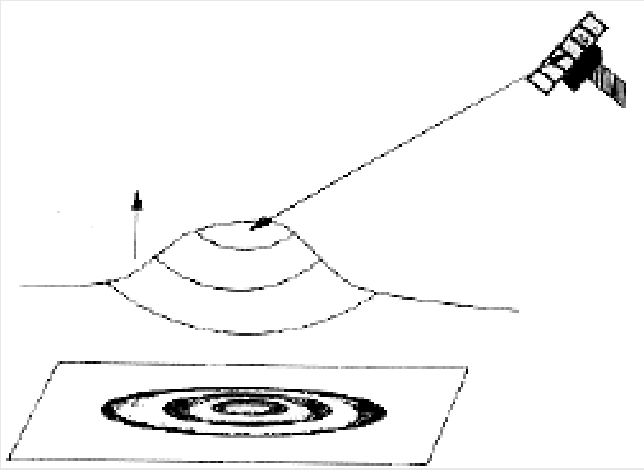


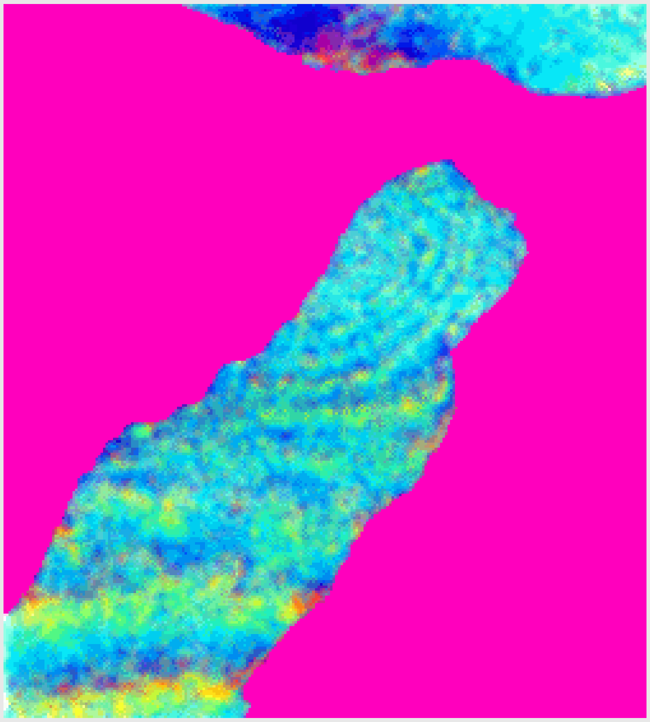
(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

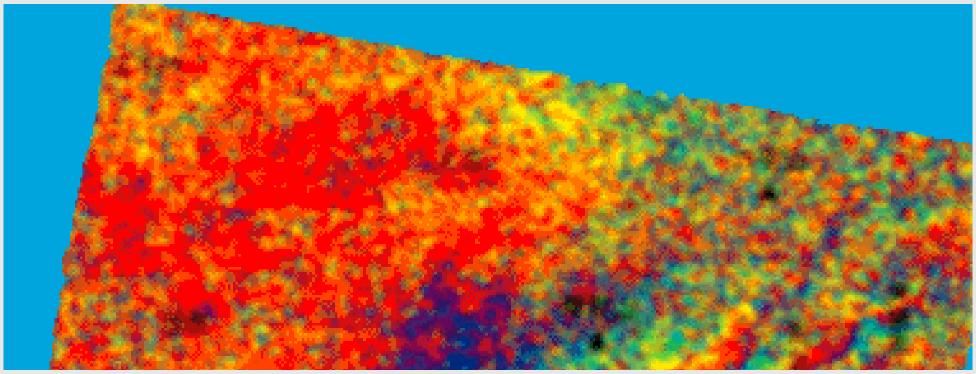
View along the fault **scarp** on Awaji Island. The section of rice paddy to the right has been uplifted by more than one meter. Note the cut road in the foreground. It is often possible to measure the displacement and length of the exposed fault rupture to estimate the **slip** and **area** of the subsurface fault, providing an independent estimate of the earthquake's magnitude.

Photo from the Japanese edition of Newsweek showing the fault scarp. Note the horizontal as well as vertical offset shown by the dike in the rice field. Well-built structures often escape major damage even so close to a seismogenic fault.

Elastic rebound, the permanent deformation of the ground due to the fault rupture, will extend many kilometers from the fault itself, and is often measurable even where the rupture itself remains buried. In the past **geodesists** have had to make painstaking and expensive surveys, visiting hundreds of field sites, to measure deformation of an area struck by an earthquake.

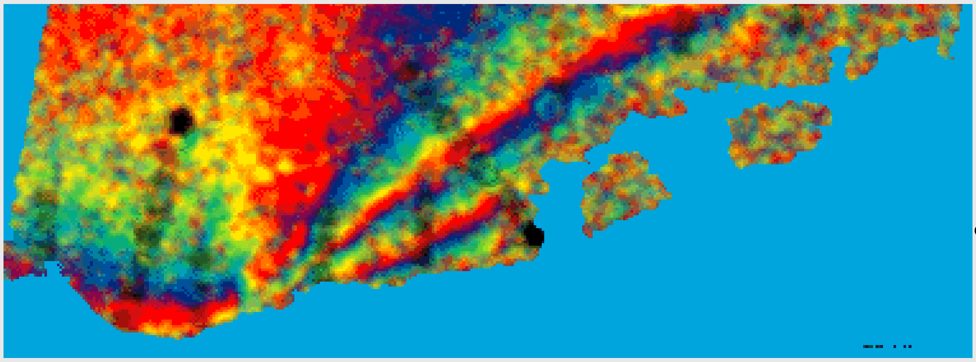






(analyzed by the Geographical Survey Institute of Japan and the National Space Development Agency of Japan; used by permission.)

Lately **planetary geophysicists** have developed a quick way to make a map image of deformation

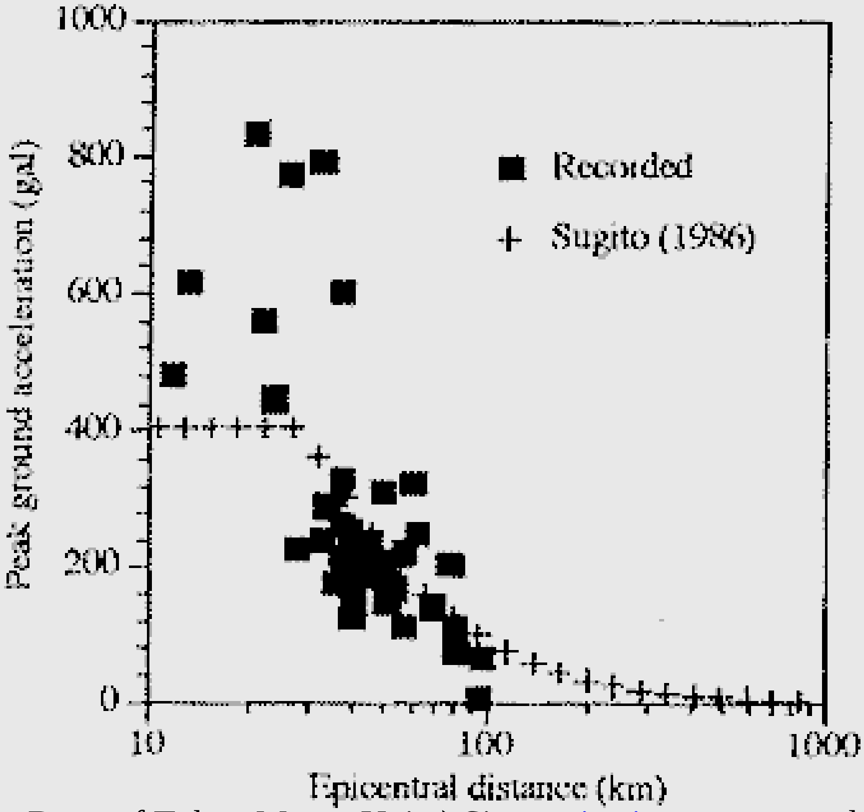


using satellite **radar interferometry**. They compare satellite microwave-radar images of a region taken before and after the event. Any area displaced toward or away from the spacecraft's positions will form an **interference pattern**, tracing out contours of equal displacement. The map image above of Awaji Island shows eight or more colored interference fringe lines approaching the fault, at 11 cm of vertical displacement per fringe contour, demonstrating almost 1 meter of uplift by the earthquake. At left, two fringes parallel the coast through the city of Kobe, showing about 20 cm of displacement across the city from the buried fault.

Secondary Effects

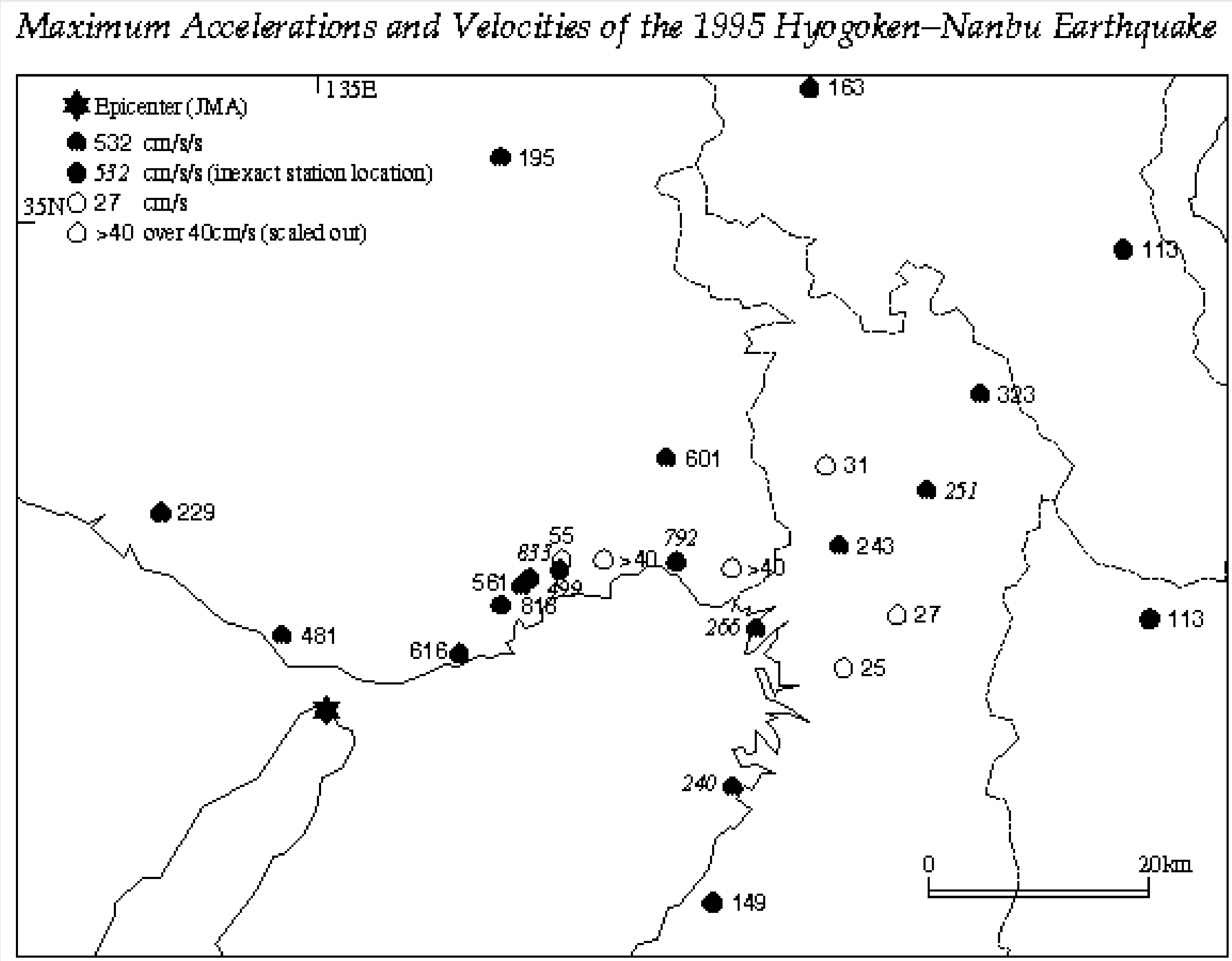
Most of the damage done by earthquakes is due to their **secondary effects**, those not directly caused by fault movement, but resulting instead from the propagation of seismic waves away from the fault rupture. Secondary effects result from the very temporary passage of seismic waves, but can occur over very large regions, causing wide-spread damage. Such effects include: **seismic shaking; landslides; liquefaction; fissuring; settlement;** and the **triggering of aftershocks and additional earthquakes**.

Seismic Shaking

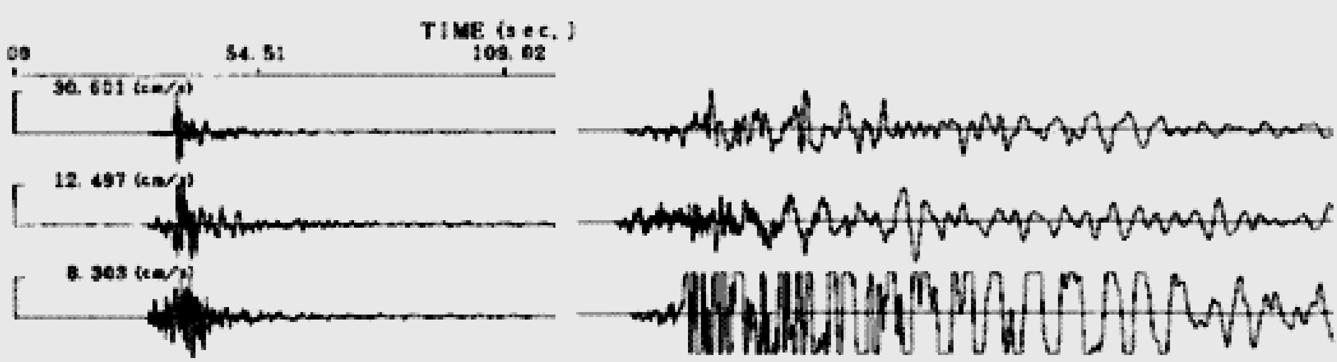


(from the Architecture Dept. of Tokyo Metro. Univ.) Since seismic waves spread out from their source just like ripples on a pond, they get weaker the farther you get from the earthquake. The **ground**

acceleration versus distance plot at left shows this effect near Kobe. An acceleration of 1000 gal for seismic waves in the ground would be equal to the acceleration of gravity; so if it acted straight up it would be able to throw any object into the air. These accelerations are mostly from side-to-side, so even at only 50% of the acceleration of gravity are capable of toppling anything standing. Note that the recorded acceleraction can vary by a factor of two or three, especially near the fault.



(compiled by the Earthquake Research Institute, Tokyo) The great differences in secondary effects even between adjacent localities is shown by this map of instrumentally-recorded ground accelerations and velocities. Although the measurements do fall with distance from the epicenter, adjacent sites can vary by more than 50%. Such variation is usually caused by variation in the soil conditions.



(from the Architecture Dept. of Tokyo Metro. Univ.) The seismograms above were recoded at two different sites near Kobe. On the left are three records of the sharp pulse, lasting less than 15 s, recorded at a station founded in relatively **solid rock**. On the right are three records of the strong and extended shaking, lasting two or even three minutes, at sites near the coast having **soft, thick, water-saturated soils**. The geological conditions right at a particular site play a crucial role in the strength, and length, of seismic shaking that can be experienced there. In all earthquakes, low-lying areas having soft, water-saturated soils experience by far the most damage.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

Since most seismic shaking is side-to-side, a shaken structure will undergo **shear** as this house front in Kobe did. **Shear** is the bending of right angles to other angles. As it is much more difficult to shear a triangle than a rectangle, effective seismic design requires triangular bracing for shear strength.

(from Kobe University) This wooden house collapsed during the seismic shaking. It is likely that its heavy roof of ceramic tile created more shear force than its wood frame was built to resist. Tile roofs are popular in Japan.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

Behind this completely collapsed wood-frame house is a house of reinforced concrete that suffered no structural damage. The number of wood versus masonry buildings that collapsed in Kobe astonished most observers, as wood-frame structures are usually thought to be much better at resisting shear forces. Possibly the concrete house was better-designed and stronger even for its greater weight. The proportionally heavier tile roofs on wooden houses also might have been a factor.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

Another anomaly was the large number of about 20-year-old high rise buildings that collapsed at the fifth floor. The older version of the code they were built under allowed a weaker superstructure beginning at the fifth floor.

(from Kobe Univ.) This photo demonstrates the extreme danger of being in the street during seismic shaking. Signs, windows, and the entire fronts of buildings collapsed into the street. During an earthquake, it is usually much safer to find shelter under strong furniture inside than to run out of a building. Exit carefully after the shaking stops.

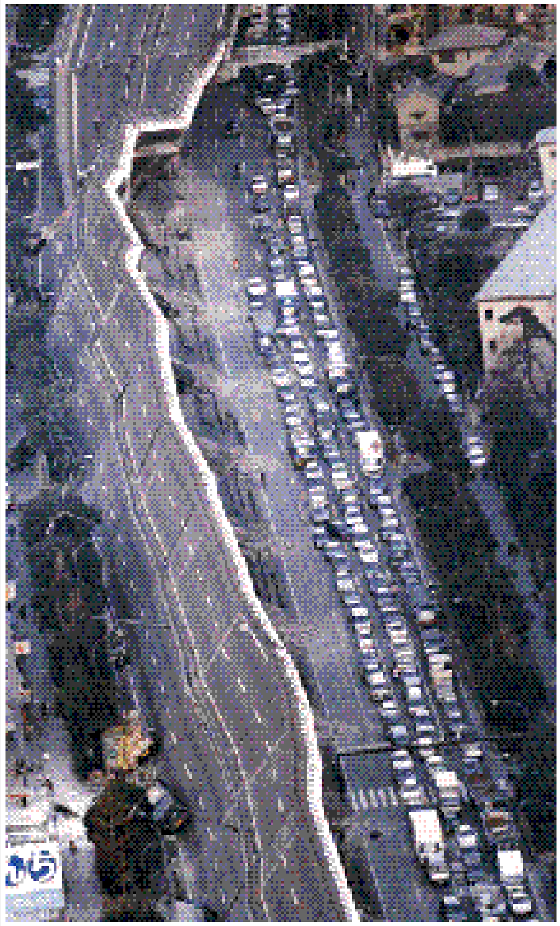
Effects on Lifelines

Debris choking streets was just one of the coincidences that made this earthquake so deadly. Almost all utilities, roadways, railways, the port, and other **lifelines** to the city center suffered severe damage, greatly delaying rescue efforts. Most lifelines in Kobe were constructed 20-30 years ago, before the most modern construction standards were put into practice.

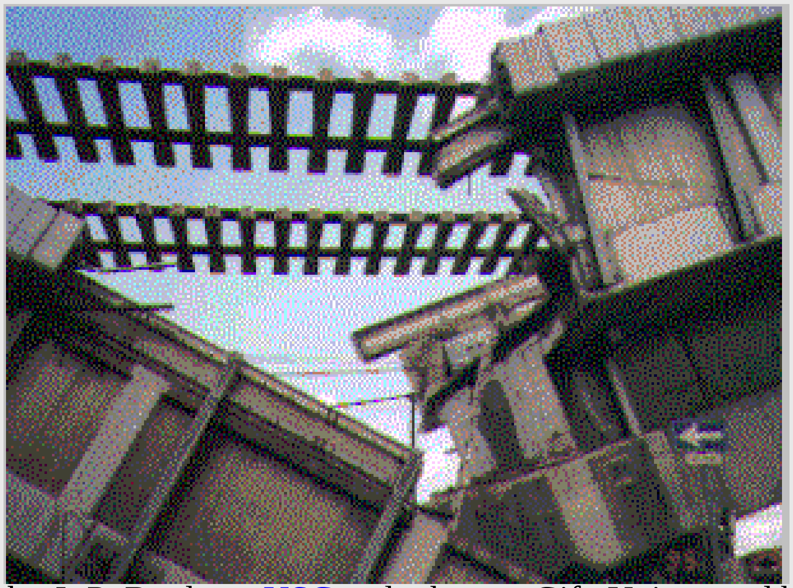
(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)
This elevated highway formed an **inverted pendulum** that the supporting columns were not able to restrain under shear during seismic shaking.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

The columns above show a failure typical of somewhat older reinforced concrete structures throughout the world. The vertical steel rods can hold the weight of the structure just fine when that weight is exerted straight down, as usual. During seismic shaking much more steel wound around the rods horizontally can keep the column from breaking apart under the shear forces. Stronger columns are more expensive to build.



(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission; and from Japanese TV) Large sections of the main Hanshin Expressway toppled over. This was particularly likely where the road crossed areas of softer, wetter ground, where the shaking was stronger and lasted longer.



(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

Many elevated structures were simply pulled apart by differential movements, here leaving the welded rails and ties suspended.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

Below one intersection a subway station collapsed, leaving the road above to sink unpredictably for months until it could be excavated.

Fire

The destruction of lifelines and utilities made it impossible for firefighters to reach fires started by broken gas lines. Large sections of the city burned, greatly contributing to the loss of life.

(from the Univ. of Texas)

Most of the destruction of San Francisco from the 1906 earthquake was also due to fire. The city installed an entirely independent water system for firefighting, with its own reservoirs. The 1989 earthquake broke a firefighting water main near the Mission Street Post Office, draining the entire system in less than 15 minutes. Fortunately most damage and fires were confined to low-lying districts of the city near the Bay, and fireboats were available to pump bay water as much as one mile inland. Only a few blocks were lost.

Liquefaction

One of the reasons that areas of soft, water-saturated soil are hazardous is their potential to **liquefy** during strong seismic shaking. The shaking can suspend sand grains in waterlogged soil so that they loose contact and friction with other grains. Soil in a state of liquefaction has no strength and cannot bear any load.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

Commonly a soil layer on the side of a hill will liquefy during seismic shaking and flow as a landslide or mudflow, as above.

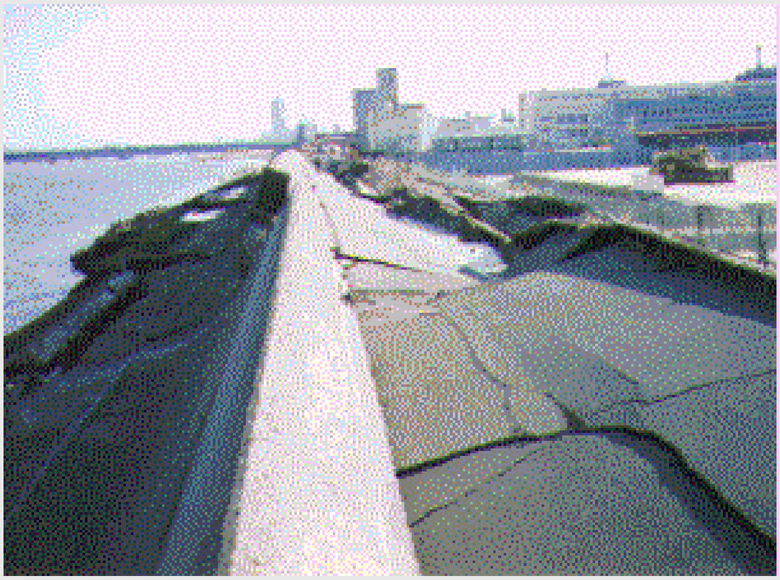
(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

A liquefied sand layer can shoot to the surface through cracks, forming a **sandblow** or **sandboil**, and depositing a characteristic lens of sand on the ground with a volcano-like vent in the center. With all the material in the layer forced to the surface, the surrounding area sinks unevenly.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

Entire levees, dams, and other water-saturated embankments can liquefy and flow apart during strong shaking.

(from Kobe Univ.) Buildings founded on liquefied ground will lean or topple.



(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

The Kobe port, having been constructed on two artificial islands made of relatively loose fill, and always water saturated, suffered widespread liquefaction and settlement, and was incapacitated for two months. Shipping was disrupted worldwide.

(from a report by J.-P. Bardet at USC and others at Gifu Univ.; used by permission)

On the port islands settlement was so pervasive that any structure built on deep pilings, like this elevated roadway, appeared to have risen a full meter. The world's longest suspension bridge, under construction but having such foundations, was hardly damaged at all.

J. Louie, 9 Oct. 1996

Previous: Richter Magnitude --- Next: Earthquake Intensity

The Modified Mercalli Scale of Earthquake Intensity

In seismology a scale of seismic **intensity** is a way of measuring or rating the *effects* of an earthquake at different sites. The **Modified Mercalli Intensity Scale is commonly used in the United States by seismologists seeking information on the severity of earthquake effects. Intensity ratings are expressed as Roman numerals between I at the low end and XII at the high end.**

The Intensity Scale differs from the Richter Magnitude Scale in that the effects of any one earthquake vary greatly from place to place, so there may be many Intensity values (e.g.: IV, VII) measured from one earthquake. Each earthquake, on the other hand, should have just one Magnitude, although the several methods of estimating it will yield slightly different values (e.g.: 6.1, 6.3).

Ratings of earthquake effects are based on the following relatively subjective scale of descriptions:

Modified Mercalli Intensity Scale

from FEMA

I. People do not feel any Earth movement.

II. A few people might notice movement if they are at rest and/or on the upper floors of tall buildings.

III. Many people indoors feel movement. Hanging objects swing back and forth. People outdoors might not realize that an earthquake is occurring.

IV. Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle. The earthquake feels like a heavy truck hitting the walls. A few people outdoors may feel movement. Parked cars rock.

V. Almost everyone feels movement. Sleeping people are awakened. Doors swing open or close. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees might shake. Liquids might spill out of open containers.

VI. Everyone feels movement. People have trouble walking. Objects fall from shelves. Pictures fall off walls. Furniture moves. Plaster in walls might crack. Trees and bushes shake. Damage is slight in poorly built buildings. No structural damage.

VII. People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.

VIII. Drivers have trouble steering. Houses that are not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Well-built buildings suffer slight damage. Poorly built structures suffer

severe damage. Tree branches break. Hillsides might crack if the ground is wet. Water levels in wells might change.

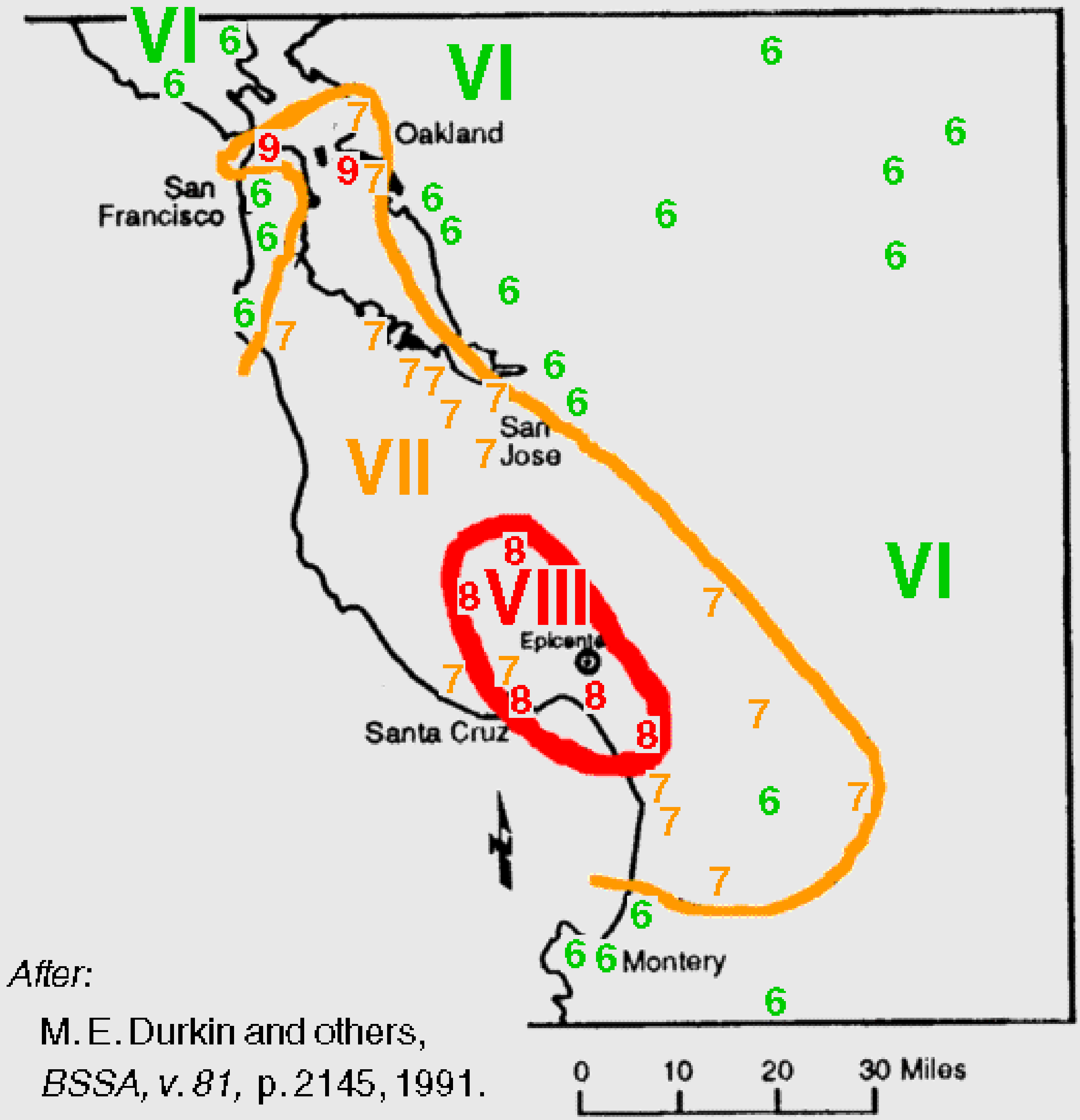
IX. Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks. Reservoirs suffer serious damage.

X. Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, lakes. The ground cracks in large areas. Railroad tracks are bent slightly.

XI. Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed. Railroad tracks are badly bent.

XII. Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

As you can see from the list above, rating the Intensity of an earthquake's effects does not require any instrumental measurements. Thus seismologists can use newspaper accounts, diaries, and other historical records to make intensity ratings of past earthquakes, for which there are no instrumental recordings. Such research helps promote our understanding of the earthquake history of a region, and estimate future hazards.



This map plots the Mercalli Intensity ratings of localities near the Oct. 17, 1989 Loma Prieta (World Series) earthquake. It is called an *isoseismal* map, as one draws contour lines to enclose locations having higher intensities. Intensities typically increase close to an earthquake's epicenter, allowing seismologists to interpret maps such as this for the general location of historical earthquakes.

Note the locations of unusually high intensities (up to IX) far north of the earthquake's epicenter, near San Francisco Bay. During this earthquake, soft and water-saturated soils near the Bay amplified the effects of the shaking. The amplified shaking, together with soil liquefaction effects, caused some well-built structures to collapse and yielded the intensity IX rating at those locations.

It is also possible to estimate the Magnitude of an earthquake from the area of the map enclosed by isoseismal contours of certain intensities. Such estimates are, however, a subject of research and require verification.

J. Louie, 10 Oct. 1996

Previous: Earthquake Effects in Kobe, Japan --- Next: Earth's Interior

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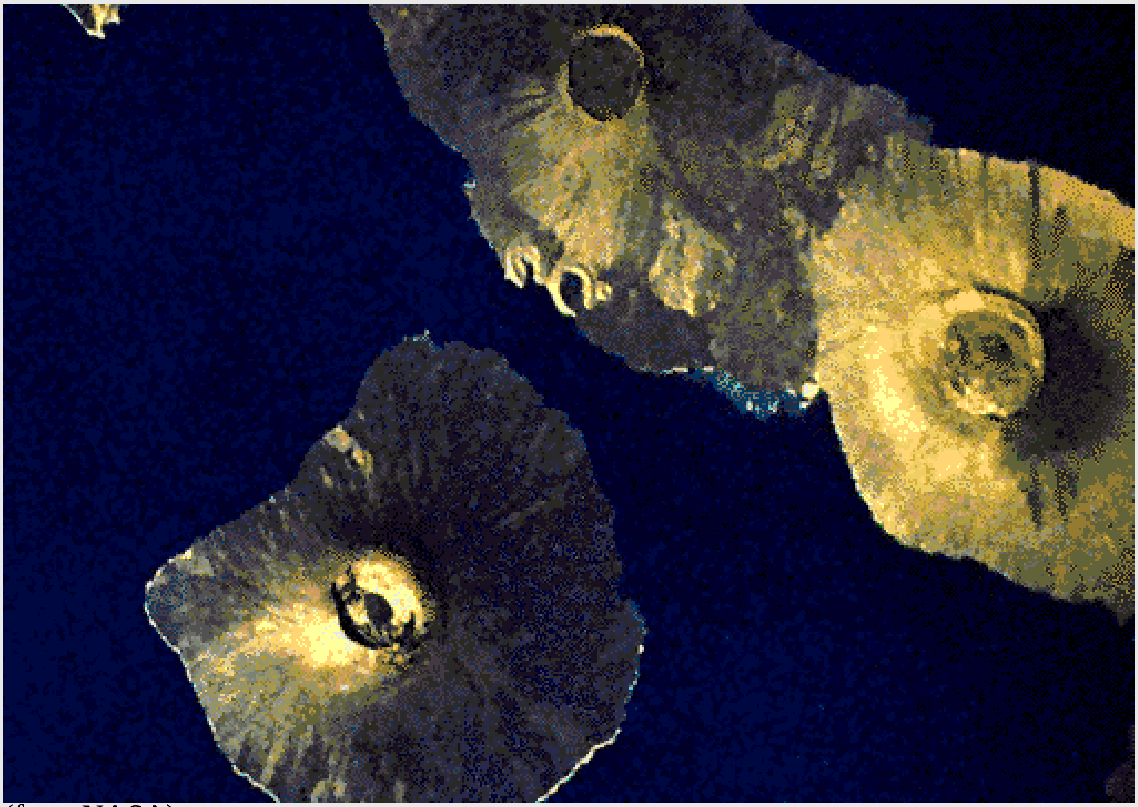
Plate Tectonics, the Cause of Earthquakes

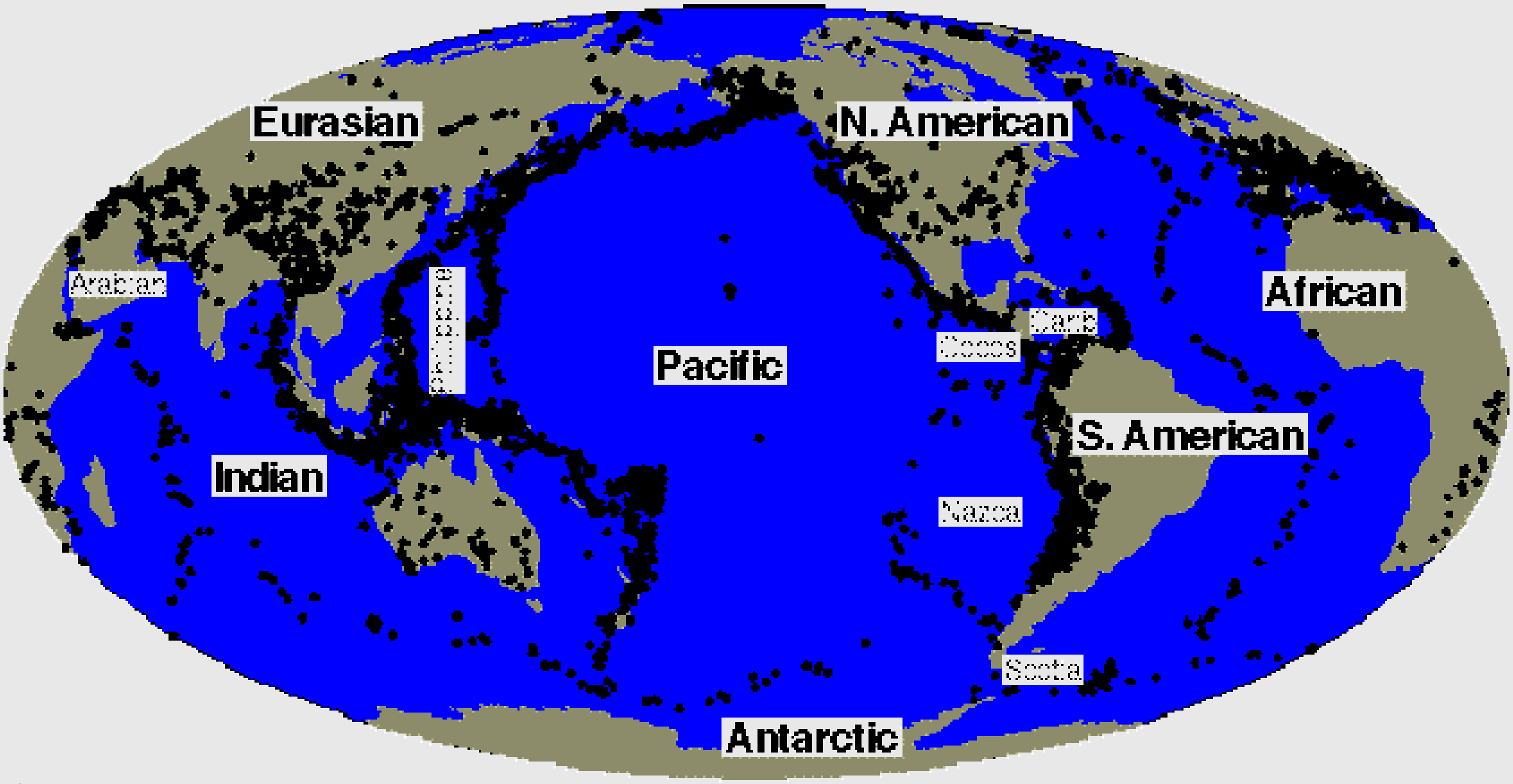
The plates consist of an outer layer of the Earth, the **lithosphere**, which is cool enough to behave as a more or less rigid shell. Occasionally the hot **asthenosphere** of the Earth finds a weak place in the lithosphere to rise buoyantly as a plume, or hotspot. The satellite image below shows the volcanic islands of the Galapagos hotspot.



(from NASA)

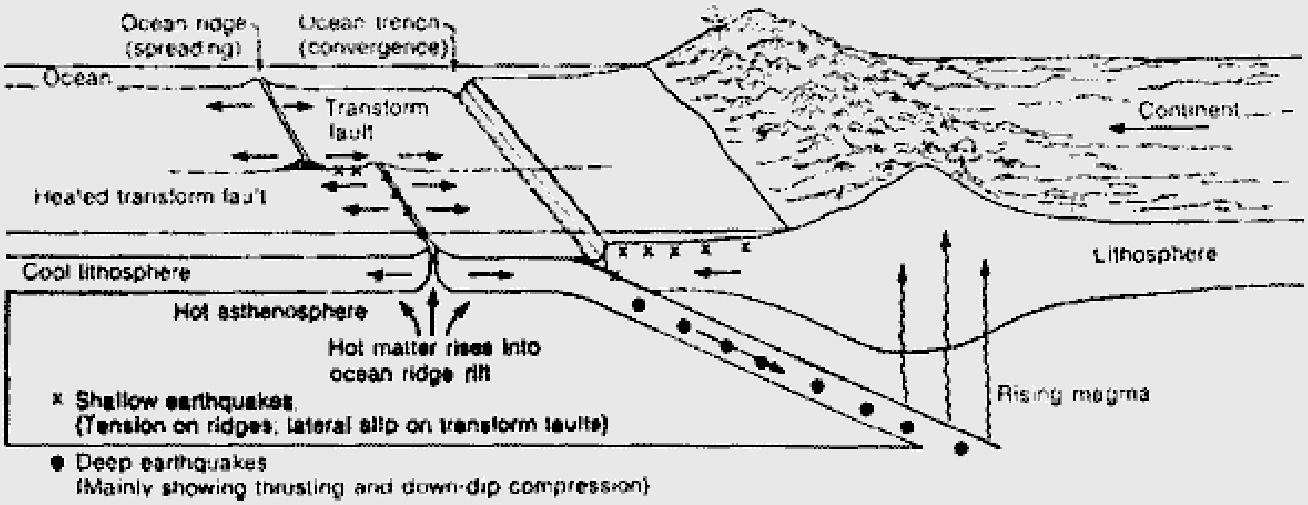
Only lithosphere has the strength and the brittle behavior to fracture in an earthquake.

The map below locates earthquakes around the globe. They are not evenly distributed; the boundaries between the plates grind against each other, producing most earthquakes. So the lines of earthquakes help define the plates:



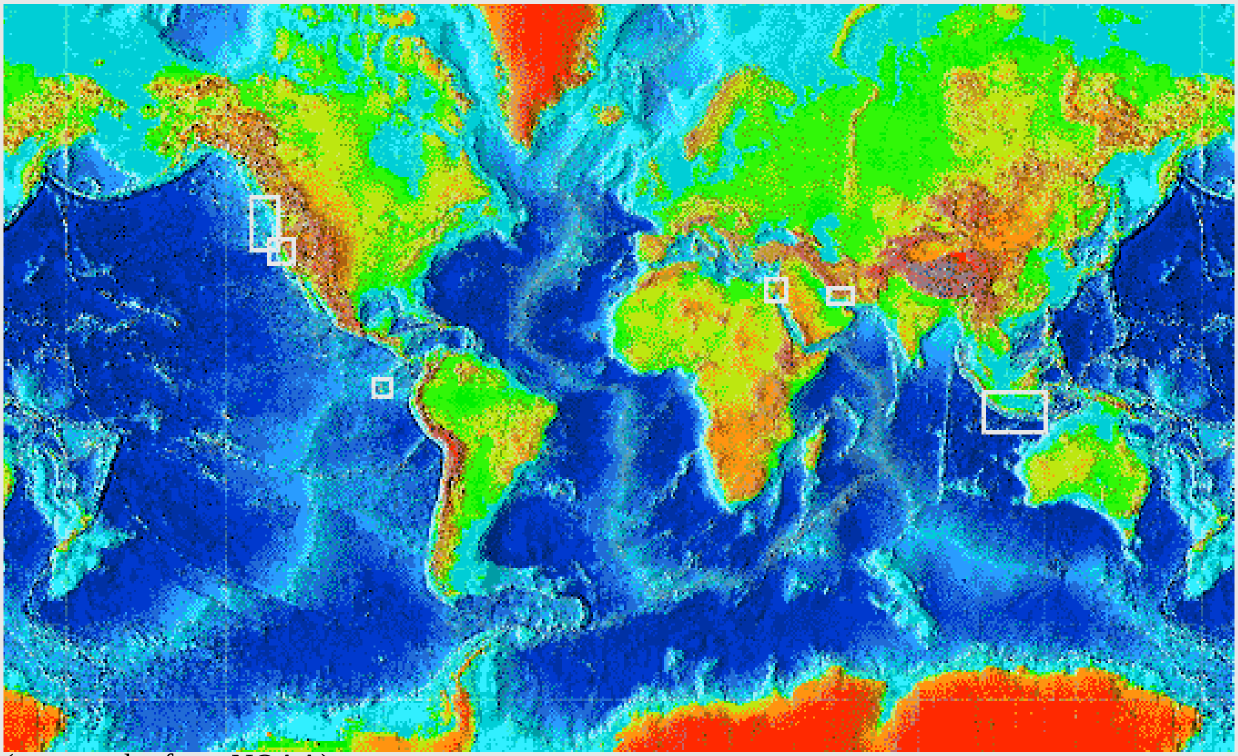
(from the USGS)

In cross section, the Earth releases its internal heat by convecting, or boiling much like a pot of pudding on the stove. Hot asthenospheric mantle rises to the surface and spreads laterally, transporting oceans and continents as on a slow conveyor belt. The speed of this motion is a few centimeters per year, about as fast as your fingernails grow. The new lithosphere, created at the ocean spreading centers, cools as it ages and eventually becomes dense enough to sink back into the mantle. The subducted crust releases water to form volcanic island chains above, and after a few hundred million years will be heated and recycled back to the spreading centers.

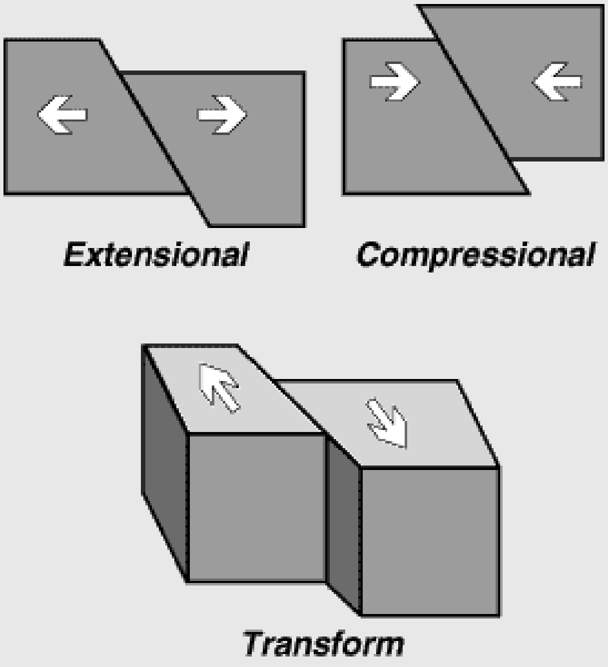


Earthquake occurrence in different plate tectonic settings:

The map below of Earth's solid surface shows many of the features caused by plate tectonics. The oceanic ridges are the asthenospheric spreading centers, creating new oceanic crust. Subduction zones appear as deep oceanic trenches. Most of the continental mountain belts occur where plates are pressing against one another. The white squares locate examples given here of the different tectonic and earthquake environments.



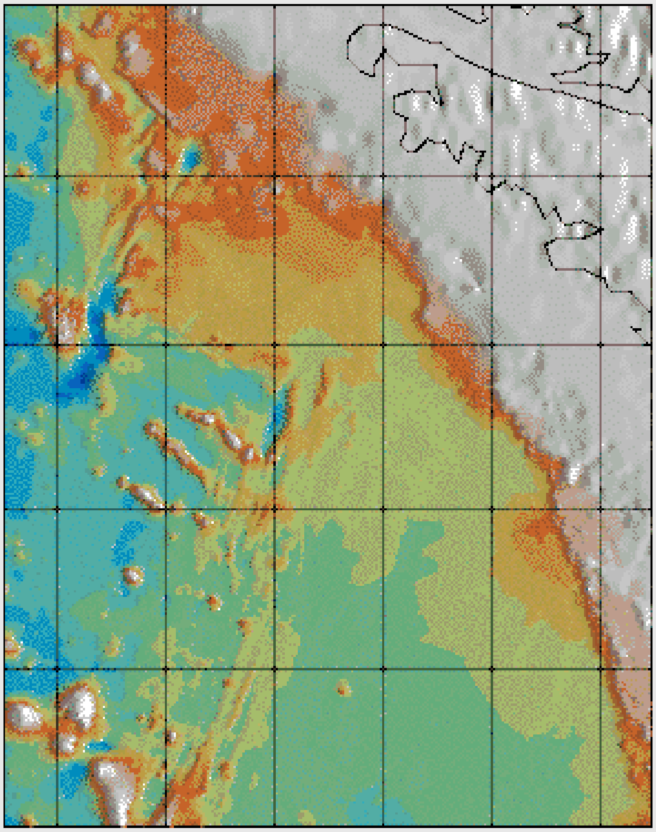
(topography from NOAA)

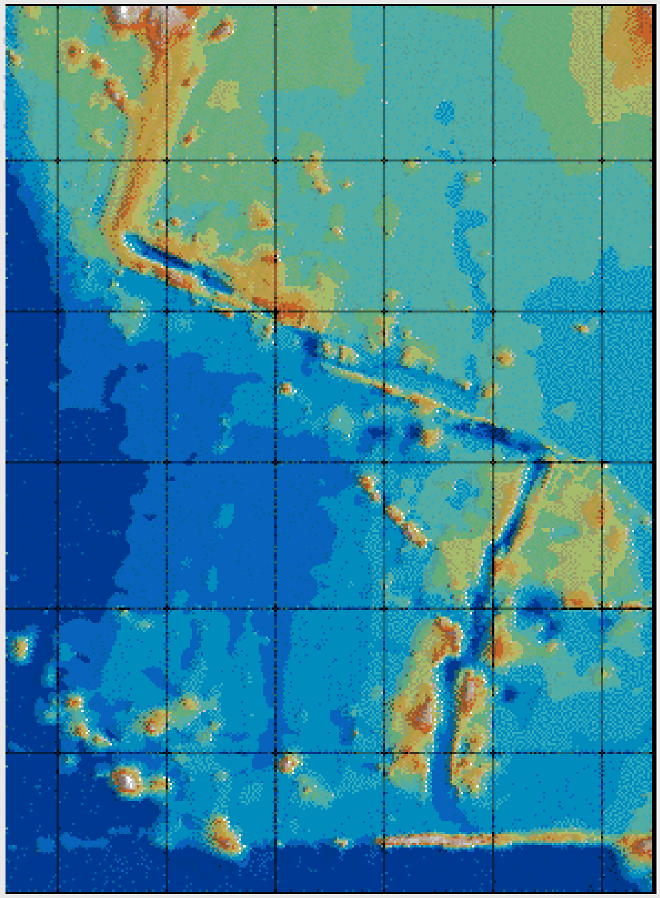


There are three main plate tectonic environments: **extensional, transform, and compressional**. Plate boundaries in different localities are subject to different inter-plate stresses, producing these three types of earthquakes. Each type has its own special hazards.

At spreading ridges, or similar *extensional* boundaries, earthquakes are shallow, aligned strictly along the axis of spreading, and show an extensional mechanism. Earthquakes in extensional environments tend to be smaller than magnitude 8. (Click here for an explanation of earthquake magnitude).

A close-up topographic picture of the Juan de Fuca spreading ridge, offshore of the Pacific Northwest, shows the turned-up edges of the spreading center. As crust moves away from the ridge it cools and sinks. The lateral offsets in the ridge are joined by transform faults.



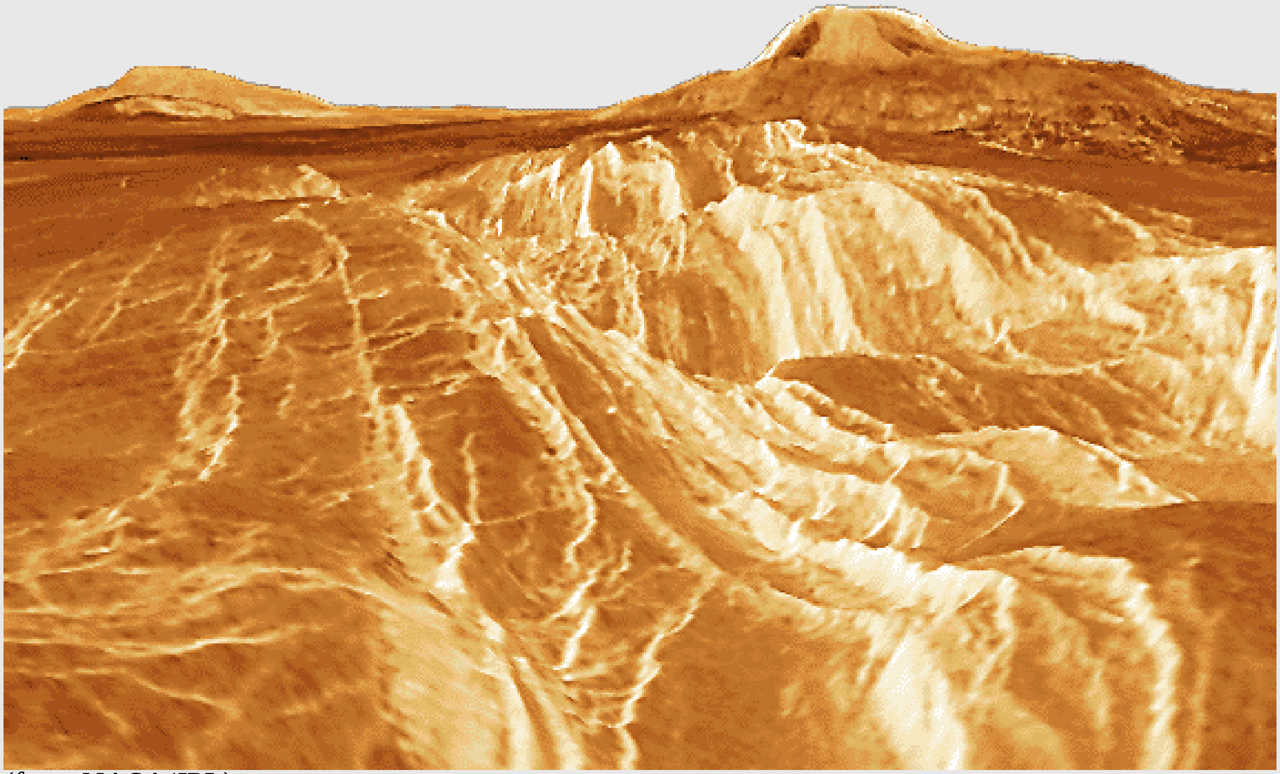


(from RIDGE, LDEO/Columbia Univ.)

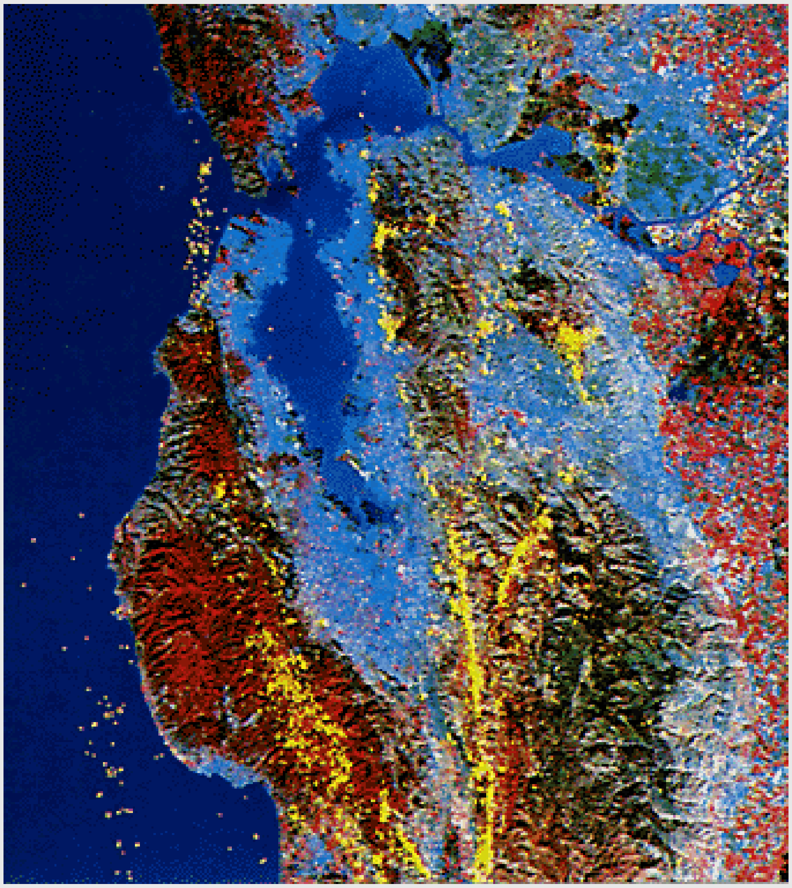
A satellite view of the Sinai shows two arms of the Red Sea spreading ridge, exposed on land.

(from NASA)

Extensional ridges exist elsewhere in the solar system, although they never attain the globe-encircling extent the oceanic ridges have on Earth. This synthetic perspective of a large volcano on Venus is looking up the large rift on its flank.



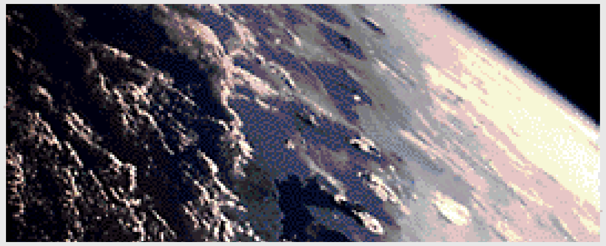
(from NASA/JPL)



(from the USGS)

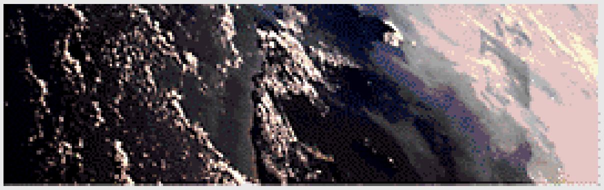
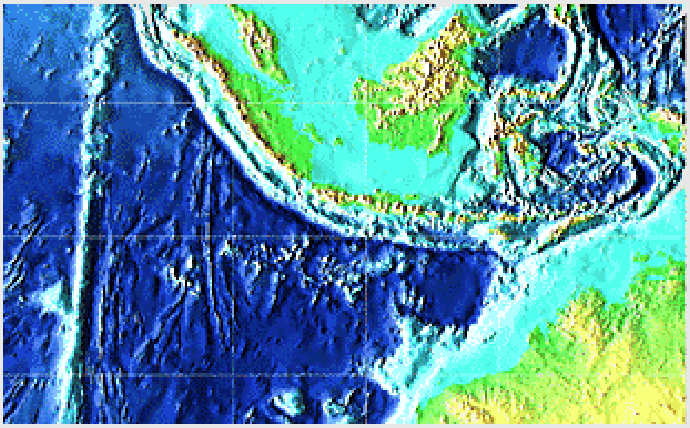
At *transforms*, earthquakes are shallow, running as deep as 25 km; mechanisms indicate strike-slip motion. Transforms tend to have earthquakes smaller than magnitude 8.5.

The San Andreas fault in California is a nearby example of a transform, separating the Pacific from the North American plate. At transforms the plates mostly slide past each other laterally, producing less sinking or lifing of the ground than extensional or compressional environments. The yellow dots below locate earthquakes along strands of this fault system in the San Francisco Bay area.



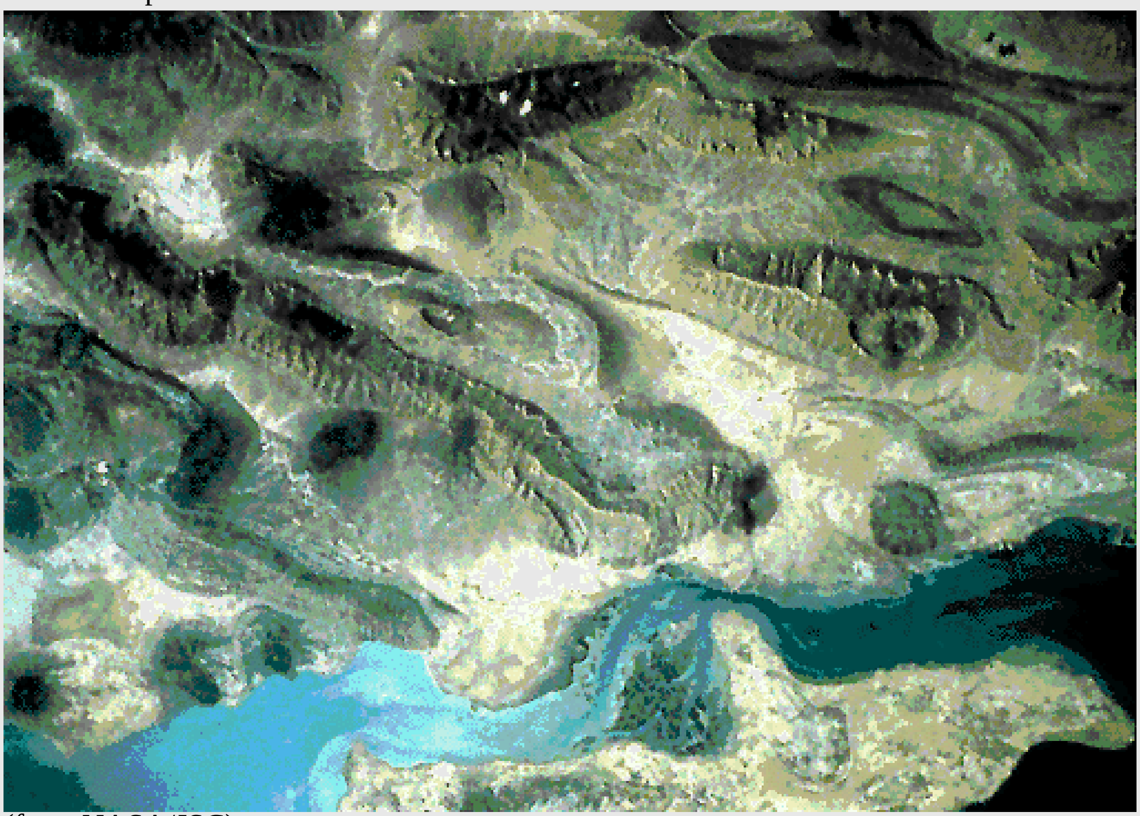
(from NASA/JSC; topography from NOAA)

At *compressional* boundaries, earthquakes are found in several settings ranging from the very near surface to several hundred kilometers depth, since the coldness of the subducting plate permits brittle failure down to as much as 700 km. Compressional boundaries host Earth's largest quakes, with some events on subduction zones in Alaska and Chile having exceeded magnitude 9.

This oblique orbital view looking east over Indonesia shows the clouded tops of the chain of large volcanoes. The topography below shows the Indian plate, streaked by hotspot traces and healed transforms, subducting at the Javan Trench.

Sometimes continental sections of plates collide; both are too light for subduction to occur. The satellite image below shows the bent and rippled rock layers of the Zagros Mountains in southern Iran, where the Arabian plate is impacting the Iranian plate.



(from NASA/JSC)

Nevada has a complex plate-tectonic environment, dominated by a combination of extensional and transform motions. The Great Basin shares some features with the great Tibetan and Anatolian plateaus. All three have large areas of high elevation, and show varying amounts of rifting and extension distributed across the regions. This is unlike oceanic spreading centers, where rifting is concentrated narrowly along the plate boundary. The numerous north-south mountain ranges that dominate the landscape from Reno to Salt Lake City are the consequence of substantial east-west extension, in which the total extension may be as much as a factor of two over the past 20 million years.

(Topo map from the Lamont-Doherty Earth Observatory of Columbia Univ.; motions added from published GPS results.)

The extension seems to be most active at the eastern and western margins of the region, i.e. the mountain fronts running near Salt Lake City and Reno. The western Great Basin also has a significant component of shearing motion superimposed on this rifting. This is part of the Pacific - North America plate motion. The total motion is about 5 cm/year. Of this, about 4 cm/yr takes place on the San Andreas fault system near the California coast, and the remainder, about 1 cm/year, occurs east of the Sierra Nevada mountains, in a zone geologists know as the Walker Lane.

As a result, Nevada hosts hundreds of active extensional faults, and several significant transform fault zones as well. While not as actively or rapidly deforming as the plate boundary in California, Nevada has earthquakes over much larger areas. While some regions in California, such as the western Sierra Nevada, appear to be isolated from earthquake activity, earthquakes have occurred everywhere in Nevada.

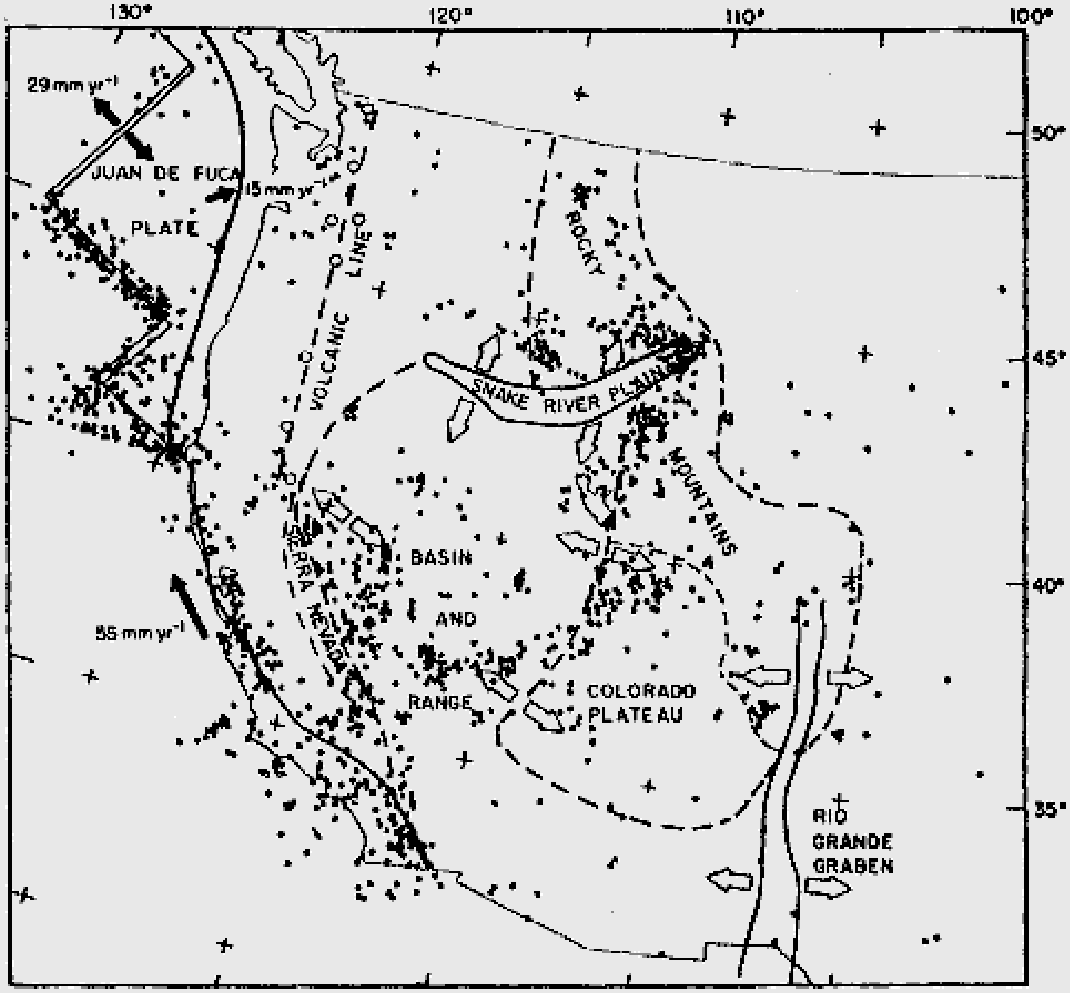


Figure 1-58 Distribution of seismicity in the geological provinces of the western United States (stars). Solid arrows give relative plate velocities; open arrows give stress directions inferred from seismic focal mechanism studies.

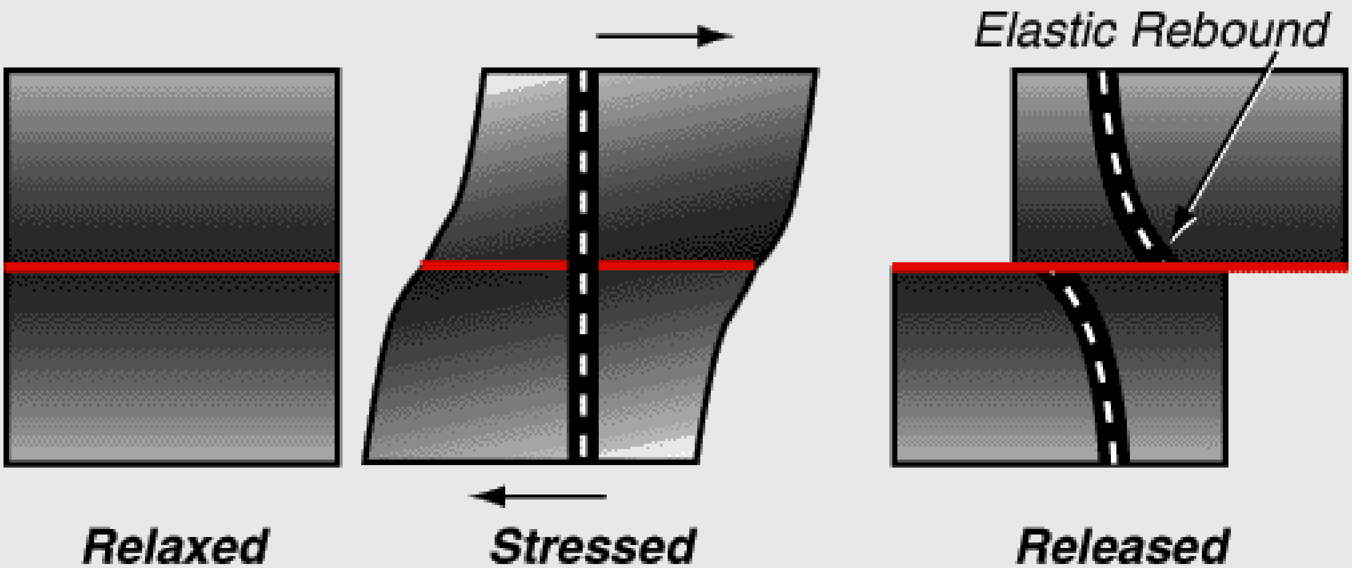
J. Louie, 11 May 2001 (with contributions from J. Anderson)

Next Lecture: Seismic Waves

More information About Earthquakes

Seismic Deformation

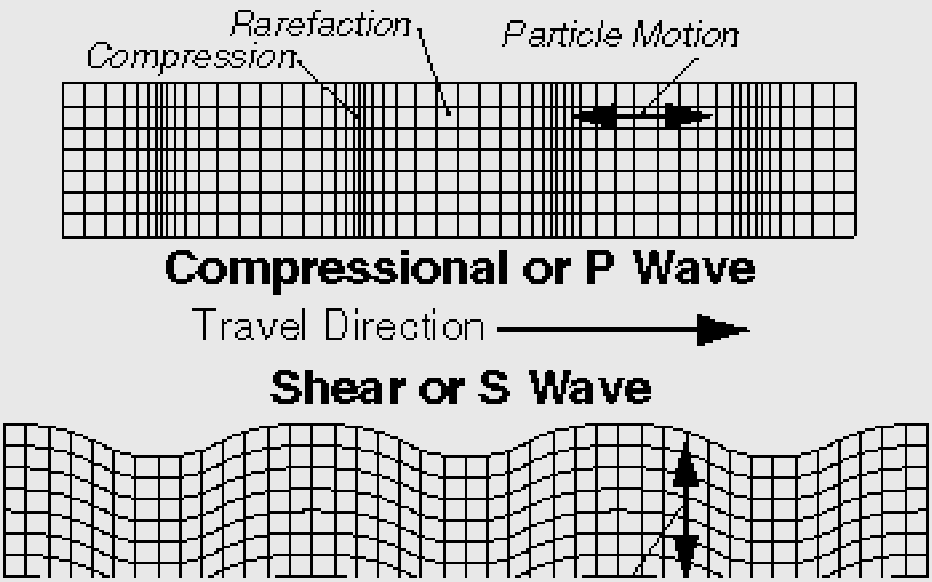
When an earthquake fault ruptures, it causes two types of deformation: **static**; and **dynamic**. Static deformation is the permanent displacement of the ground due to the event. The **earthquake cycle** progresses from a fault that is not under stress, to a stressed fault as the plate tectonic motions driving the fault slowly proceed, to rupture during an earthquake and a newly-relaxed but deformed state.



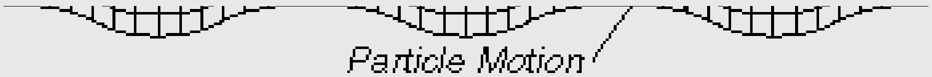
Typically, someone will build a straight reference line such as a road, railroad, pole line, or fence line across the fault while it is in the pre-rupture stressed state. After the earthquake, the formerly stright line is distorted into a shape having increasing displacement near the fault, a process known as **elastic rebound**.

Seismic Waves

The second type of deformation, dynamic motions, are essentially sound waves radiated from the earthquake as it ruptures. While most of the plate-tectonic energy driving fault ruptures is taken up by static deformation, up to 10% may dissipate immediately in the form of **seismic waves**.



The mechanical properties of the rocks that seismic waves travel through quickly organize the waves into two types. Compressional waves, also known as primary or P waves, travel fastest, at speeds between 1.5 and 8 kilometers per second in the Earth's crust. Shear waves, also known as secondary or S waves, travel more slowly, usually at 60% to 70% of the speed of P waves.

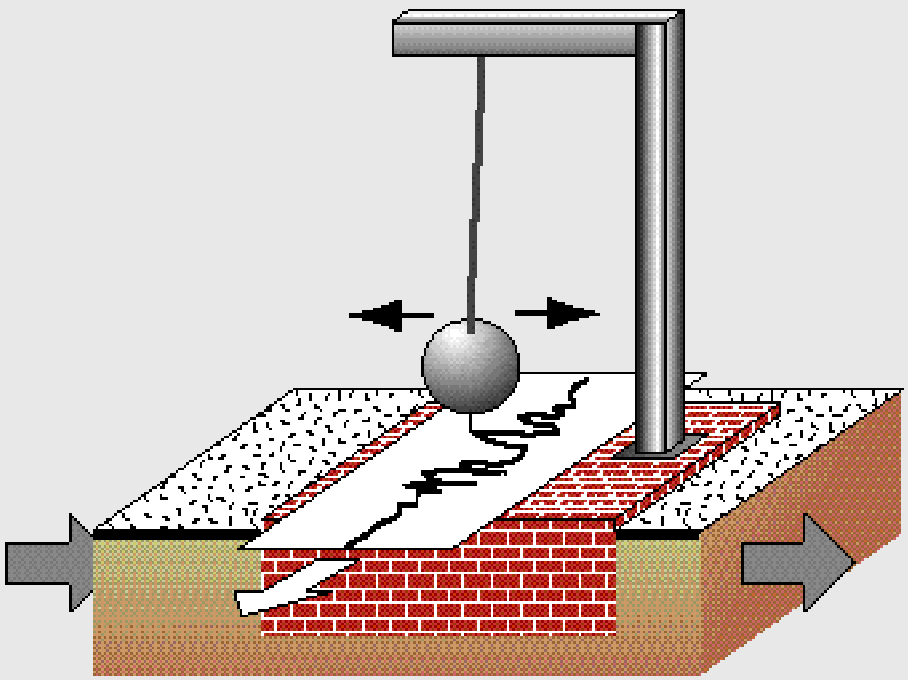


P waves shake the ground in the direction they are propagating, while S waves shake perpendicularly or **transverse** to the direction of propagation.

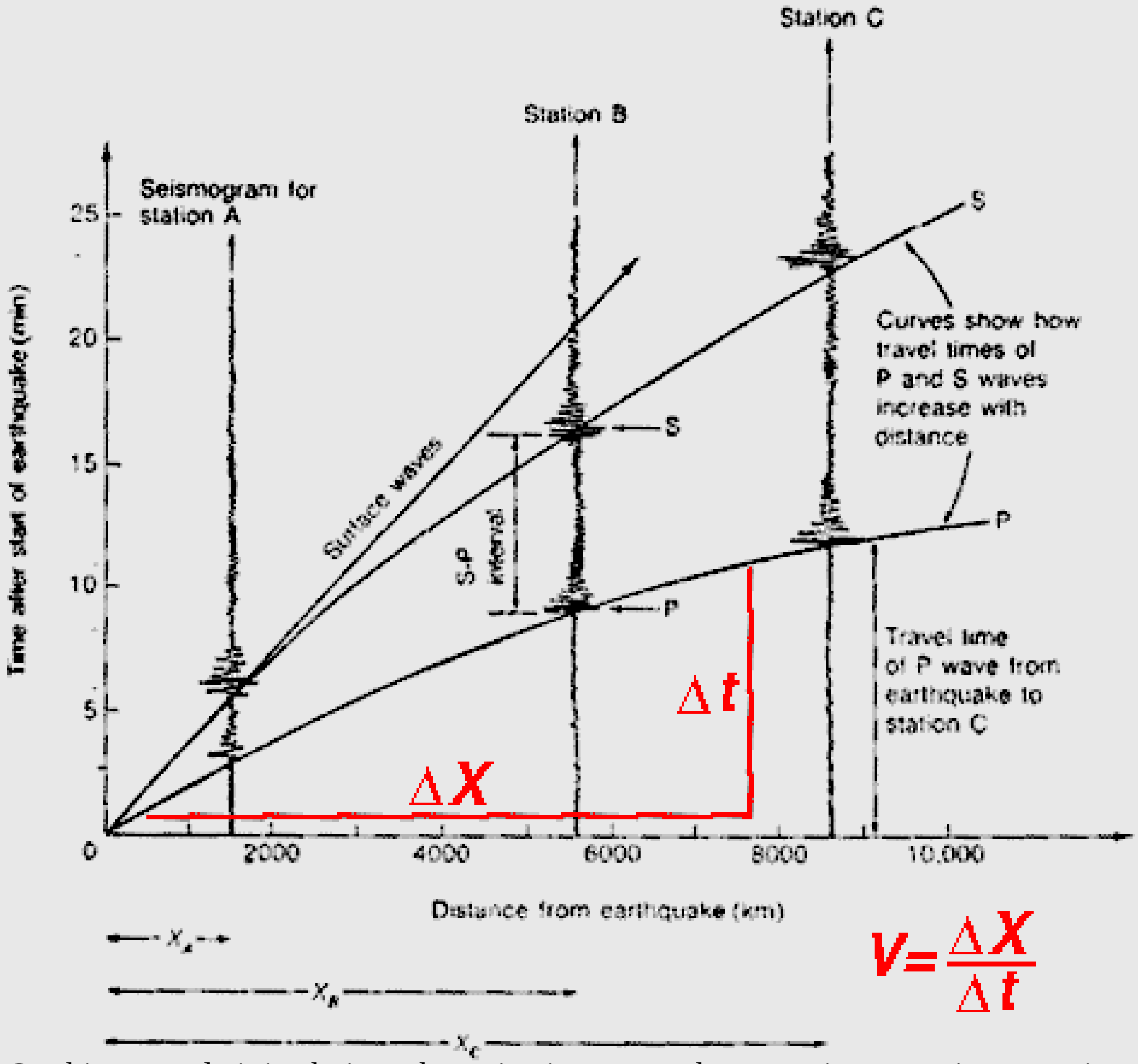
Although wave speeds vary by a factor of ten or more in the Earth, the ratio between the average speeds of a P wave and of its following S wave is quite constant. This fact enables seismologists to simply time the delay between the arrival of the P wave and the arrival of the S wave to get a quick and reasonably accurate estimate of the distance of the earthquake from the observation station. Just multiply the S-minus-P (S-P) time, in seconds, by the factor 8 km/s to get the approximate distance in kilometers.

The dynamic, transient seismic waves from any substantial earthquake will propagate all around and entirely through the Earth. Given a sensitive enough detector, it is possible to record the seismic waves from even minor events occurring anywhere in the world at any other location on the globe. Nuclear test-ban treaties in effect today rely on our ability to detect a nuclear explosion anywhere equivalent to an earthquake as small as Richter Magnitude 3.5.

Seismographs and Seismograms



Sensitive **seismographs** are the principal tool of scientists who study earthquakes. Thousands of seismograph stations are in operation throughout the world, and instruments have been transported to the Moon, Mars, and Venus. Fundamentally, a seismograph is a simple pendulum. When the ground shakes, the base and frame of the instrument move with it, but intertia keeps the pendulum bob in place. It will then appear to move, relative to the shaking ground. As it moves it records the pendulum displacements as they change with time, tracing out a record called a **seismogram**.
One seismograph station, having three different pendulums sensitive to the north-south, east-west, and vertical motions of the ground, will record seismograms that allow scientists to estimate the distance, direction, Richter Magnitude, and type of faulting of the earthquake. Seismologists use **networks** of seismograph stations to determine the location of an earthquake, and better estimate its other parameters. It is often revealing to examine seismograms recorded at a range of distances from an earthquake:



On this example it is obvious that seismic waves take more time to arrive at stations that are farther away. The average velocity of the wave is just the slope of the line connecting arrivals, or the change in distance divided by the change in time. Variations in such slopes reveal variations in the seismic velocities of rocks. Note the secondary S-wave arrivals that have larger amplitudes than the first P waves, and connect at a smaller slope.

While the actual frequencies of seismic waves are below the range of human hearing, it is possible to speed up a recorded seismogram to hear it. You can click on this earthquake recording to hear a seismogram from the 1992 Landers earthquake in southern California, recorded near Mammoth Lakes in an active volcanic caldera by the USGS. The original record, 800 seconds long, has been speeded up 80 times so that you hear it all within 10 seconds.

75 kb u-law; 149 kb WAV; 75 kb Quicktime

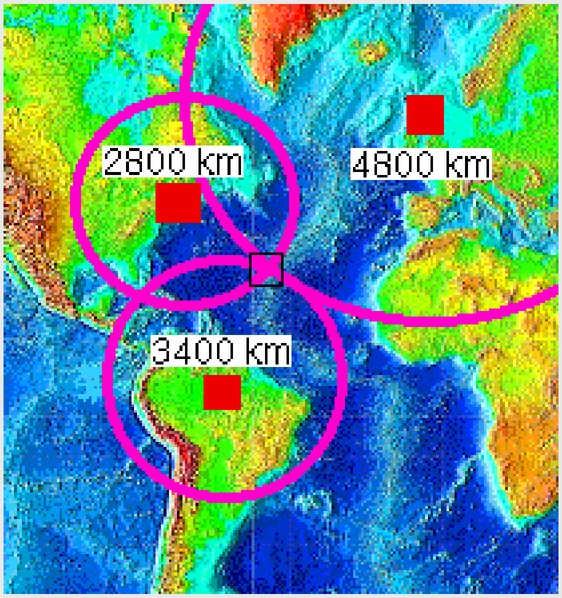
The clicks at the beginning of the recording are the sharp, high-frequency P waves, followed by the rushing sound of the drawn-out, lower-frequency S waves. This recording is also interesting because of the small, local earthquakes within the Mammoth caldera that sound like gunshots. The passage of the S wave from the magnitude 7.2 Landers event through the caldera actually triggered a sequence of small earthquakes there. The triggered earthquakes are similar to a burst of creaks and pops you hear from your house frame after a strong blast of wind. Landers triggered earthquakes up to magnitude 5.5 throughout eastern California and Nevada, and in calderas as far away as Yellowstone.

Listen to more earthquakes with:

- John Louie's *The Sound of Seismic* (MP3s)
- Andy Michael and Dennis Ross's *Listening to Earthquakes* (WAVs)

Locating Earthquakes

The pricipal use of seismograph networks is to **locate** earthquakes. Although it is possible to infer a general location for an event from the records of a single station, it is most accurate to use three or more stations. Locating the source of any earthquake is important, of course, in assessing the damage that the event may have caused, and in relating the earthquake to its geologic setting.



Given a single seismic station, the seismogram records will yield a measurement of the S-P time, and thus the distance between the station and the event. Multiply the seconds of S-P time by 8 km/s for the kilometers of distance. Drawing a circle on a map around the station's location, with a radius equal to the distance, shows all possible locations for the event. With the S-P time from a second station, the circle around that station will narrow the possible locations down to two points. It is only with a third station's S-P time that you can draw a third circle that should identify which of the two previous possible points is the real one:

This example uses stations in Boston, Edinborough, and Manaus. With the distances shown, all three circles can intersect only at a single point on the Mid-Atlantic Ridge spreading center.

J. Louie, 7 Oct. 1996

Previous: Plate Tectonics --- Next: Richter Magnitude

What is Richter Magnitude?

Short answer:

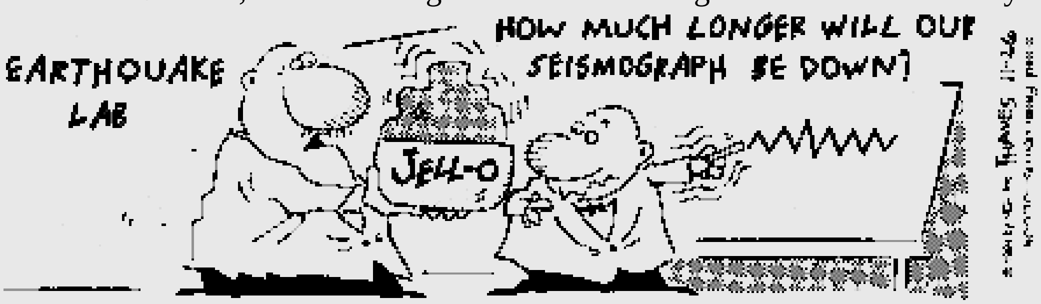
Seismologists use a **Magnitude** scale to express the seismic energy released by each earthquake. Here are the typical effects of earthquakes in various magnitude ranges:

Earthquake Severity

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0-7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Although each earthquake has a unique **Magnitude**, its effects will vary greatly according to distance, ground conditions, construction standards, and other factors. Seismologists use a different Mercalli **Intensity** Scale to express the variable effects of an earthquake.

Each earthquake has a unique amount of energy, but magnitude values given by different seismological observatories for an event may vary. Depending on the size, nature, and location of an earthquake, seismologists use several different methods to estimate magnitude. The uncertainty in an estimate of the magnitude is about plus or minus 0.3 units, and seismologists often revise magnitude estimates as they obtain and analyze additional data.

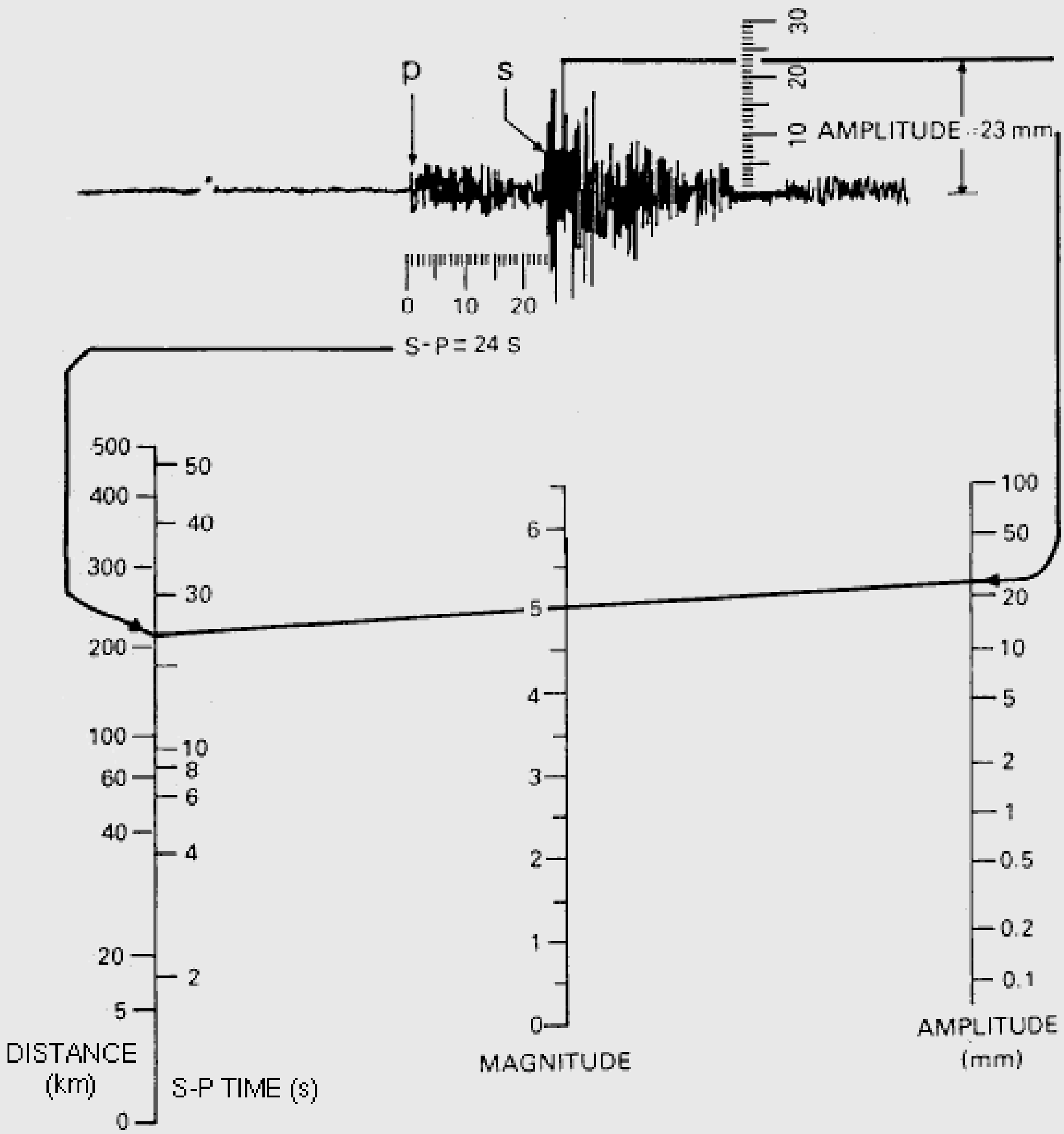


Long answer:

One of **Dr. Charles F. Richter**'s most valuable contributions was to recognize that the **seismic waves** radiated by all earthquakes can provide good estimates of their magnitudes. You can read about seismic waves by clicking here. He collected the recordings of seismic waves from a large number of earthquakes, and developed a calibrated system of measuring them for magnitude.

Richter showed that, the larger the intrinsic energy of the earthquake, the larger the **amplitude** of ground motion at a given distance. He calibrated his scale of magnitudes using measured maximum amplitudes of shear waves on seismometers particularly sensitive to shear waves with periods of about one second. The records had to be obtained from a specific kind of instrument, called a **Wood-Anderson seismograph**. Although his work was originally calibrated only for these specific seismometers, and only for earthquakes in southern California, seismologists have developed scale factors to extend Richter's magnitude scale to many other types of measurements on all types of seismometers, all over the world. In fact, magnitude estimates have been made for thousands of Moon-quakes and for two quakes on Mars.

The diagram below demonstrates how to use Richter's original method to measure a seismogram for a magnitude estimate in Southern California:



The scales in the diagram above form a **nomogram** that allows you to do the mathematical computation quickly by eye. The equation for Richter Magnitude is:

$$M_L = \log_{10}A(mm) + (Distance\ correction\ factor)$$

Here *A* is the amplitude, in millimeters, measured directly from the photographic paper record of the **Wood-Anderson** seismometer, a special type of instrument. The *distance factor* comes from a table that can be found in Richter's (1958) book *Elementary Seismology*. The equation behind this nomogram, used by Richter in Southern California, is:

$$M = \log_{10}A(mm) + 3\log_{10}[8\Delta t(s)] - 2.92$$

Thus after you measure the wave amplitude you have to take its **logarithm**, and scale it according to the distance of the seismometer from the earthquake, estimated by the S-P time difference. The S-P time, in seconds, makes Δt.

Click here to learn more about the mathematical logarithm.

Seismologists will try to get a separate magnitude estimate from every seismograph station that records the earthquake, and then average them. This accounts for the usual spread of around 0.2 magnitude units that you see reported from different seismological labs right after an earthquake. Each lab is averaging in different stations that they have access to. It may be several days before different organizations will come to a consensus on what was the best magnitude estimate.

Seismic Moment:

Seismologists have more recently developed a standard magnitude scale that is completely independent of the type of instrument. It is called the **moment magnitude**, and it comes from the **seismic moment**.

To get an idea of the seismic moment, we go back to the elementary physics concept of torque. A torque is a force that changes the angular momentum of a system. It is defined as the force times the distance from the center of rotation. Earthquakes are caused by internal torques, from the interactions of different blocks of the earth on opposite sides of faults. After some rather complicated mathematics, it can be shown that the moment of an earthquake is simply expressed by:

$$(Moment) = (Rock\ Rigidity) \times (Fault\ Area) \times (Slip\ Distance)$$

$$M_0 = \mu A d$$

$$(dyne\text{-}cm) = \left[\frac{dyne}{\cancel{cm^2}}\right] \times (\cancel{cm^2}) \times (cm)$$

The formula above, for the **moment** of an earthquake, is fundamental to seismologists' understanding of how dangerous faults of a certain size can be.

Now, let's imagine a chunk of rock on a lab bench, the rigidity, or resistance to shearing, of the rock is a **pressure** in the neighborhood of a few hundred billion dynes per square centimeter. (Scientific notation makes this easier to write.) The **pressure** acts over an **area** to produce a force, and you can see that the cm-squared units cancel. Now if we guess that the distance the two parts grind together before they fly apart is about a centimeter, then we can calculate the moment, in dyne-cm:

$$M_0 = (3\times10^{11}\ \frac{dyne}{\cancel{cm^2}})(10\ \cancel{cm})(10\ \cancel{cm})(1\ cm)$$

$$M_0 = (3\times10^{11})(10^2)(dyne-cm)$$

$$M_0 = 3\times10^{13}\ dyne-cm$$

Again it is helpful to use scientific notation, since a dyne-cm is really a puny amount of moment.

Now let's consider a second case, the Sept. 12, 1994 Double Spring Flat earthquake, which occurred about 25 km southeast of Gardnerville. The first thing we have to do, since we're working in centimeters, is figure out how to convert the 15 kilometer length and 10 km depth of that fault to centimeters. We know that 100 thousand centimeters equal one kilometer, so we can write that equation and divide both sides by "km" to get a factor equal to one.

$$1\ km = 10^5\ cm \qquad\qquad 1 = \frac{10^5\ cm}{km}$$

Of course we can multiply anything by one without changing it, so we use it to cancel the kilometer units and put in the right centimeter units:

$$M_0 = (3\times10^{11}\ \frac{dyne}{\cancel{cm^2}})(10\ \cancel{km})\left[\frac{10^5\ \cancel{cm}}{\cancel{km}}\right](15\ \cancel{km})\left[\frac{10^5\ \cancel{cm}}{\cancel{km}}\right](30\ cm)$$

$$M_0 = 1.1\times10^{25}\ dyne-cm$$

Of course this result needs scientific notation even more desperately. We can see that this earthquake, the largest in Nevada in 28 years, had two times ten raised to the twelfth power, or 2 trillion, times as much moment as breaking the rock on the lab table.

There is a standard way to convert a seismic moment to a **magnitude**. The equation is:

$$M_w = \frac{2}{3}\left[\log_{10} M_0\ (dyne-cm) - 16.0\right]$$

Now let's use this equation (meant for energies expressed in dyne-cm units) to estimate the **magnitude** of the tiny earthquake we can make on a lab table:

$$M_0 = 3\times10^{13}\ dyne-cm$$

$$M_w = \frac{2}{3}\left[\log_{10}(3\times10^{13} dyne-cm) - 16.0\right]$$

$$M_w = \frac{2}{3}\left[\sim13.5 - 16.0\right]$$

$$M_w \sim \frac{2}{3}(-2.5)$$

$$M_w \sim -1.7$$

Negative magnitudes are allowed on Richter's scale, although such earthquakes are certainly very small.

Next let's take the energy we found for the Double Spring Flat earthquake and estimate its magnitude:

$$M_0 = 1.4\times10^{25}$$

$$M_w = \frac{2}{3}\left[\log_{10}(1.4\times10^{25}\,dyne-cm) - 16.0\right]$$

$$M_w = \frac{2}{3}\left[\sim25.2 - 16.0\right]$$

$$M_w \sim \frac{2}{3}(9.2)$$

$$M_w \sim 6.1$$

The magnitude 6.1 value we get is about equal to the magnitude reported by the UNR Seismological Lab, and by other observers.

Seismic Energy:

Both the magnitude and the seismic moment are related to the amount of energy that is radiated by an earthquake. Richter, working with **Dr. Beno Gutenberg**, early on developed a relationship between magnitude and energy. Their relationship is:

$$\log E_S = 11.8 + 1.5M$$

giving the energy E_S in **erg**s from the magnitude M. Note that E_S is not the total ``intrinsic" energy of the earthquake, transferred from sources such as gravitational energy or to sinks such as heat energy. It is only the amount radiated from the earthquake as seismic waves, which ought to be a small fraction of the total energy transfered during the earthquake process.

More recently, **Dr. Hiroo Kanamori** came up with a relationship between seismic moment and seismic wave energy. It gives:

$$Energy = (Moment)/20{,}000$$

For this moment is in units of dyne-cm, and energy is in units of ergs. dyne-cm and ergs are unit equivalents, but have different physical meaning.

Let's take a look at the seismic wave energy yielded by our two examples, in comparison to that of a number of earthquakes and other phenomena. For this we'll use a larger unit of energy, the seismic energy yield of quantities of the explosive TNT (We assume one ounce of TNT exploded below ground yields 640 million ergs of seismic wave energy):

Richter Magnitude	TNT for Seismic Energy Yield	Example (approximate)
-1.5	6 ounces	Breaking a rock on a lab table
1.0	30 pounds	Large Blast at a Construction Site
1.5	320 pounds	
2.0	1 ton	Large Quarry or Mine Blast
2.5	4.6 tons	
3.0	29 tons	

3.5	73 tons	
4.0	1,000 tons	Small Nuclear Weapon
4.5	5,100 tons	Average Tornado (total energy)
5.0	32,000 tons	
5.5	80,000 tons	Little Skull Mtn., NV Quake, 1992
6.0	1 million tons	Double Spring Flat, NV Quake, 1994
6.5	5 million tons	Northridge, CA Quake, 1994
7.0	32 million tons	Hyogo-Ken Nanbu, Japan Quake, 1995; Largest Thermonuclear Weapon
7.5	160 million tons	Landers, CA Quake, 1992
8.0	1 billion tons	San Francisco, CA Quake, 1906
8.5	5 billion tons	Anchorage, AK Quake, 1964
9.0	32 billion tons	Chilean Quake, 1960
10.0	1 trillion tons	(San-Andreas type fault circling Earth)
12.0	160 trillion tons	(Fault Earth in half through center, OR Earth's daily receipt of solar energy)

---

160 trillion tons of dynamite is a frightening yield of energy. Consider, however, that the Earth receives that amount in **sunlight** every day.

Practical ways of estimating magnitude

Most seismologists prefer to use the seismic moment to estimate earthquake magnitudes. Finding an earthquake fault's length, depth, and its slip can take several days, weeks, or even months after a big earthquake. Geologists' mapping of the earthquake's fault breaks, or seismologists' plotting of the spatial distribution of aftershocks, can give these parameters after a substantial effort. But some large earthquakes, and most small earthquakes, show neither surface fault breaks nor enough aftershocks to estimate magnitudes the way we have above. However, seismologists have developed ways to estimate the seismic moment directly from seismograms using computer processing methods. The Centroid Moment Tensor Project at Harvard University has been routinely estimating moments of large earthquakes around the world by seismogram inversion since 1982.

Another measure of an earthquake

Seismologists use a separate method to estimate the **effects** of an earthquake, called its **intensity**. **Intensity** should not be confused with **magnitude**. Although each earthquake has a single magnitude value, its effects will vary from place to place, and there will be many different intensity estimates. You can read about the Mercalli Intensity Scale, one popular way to characterize earthquake effects.

J. Louie, 9 Oct. 1996

Previous: Seismic Waves --- Next: Earthquake Effects in Kobe, Japan

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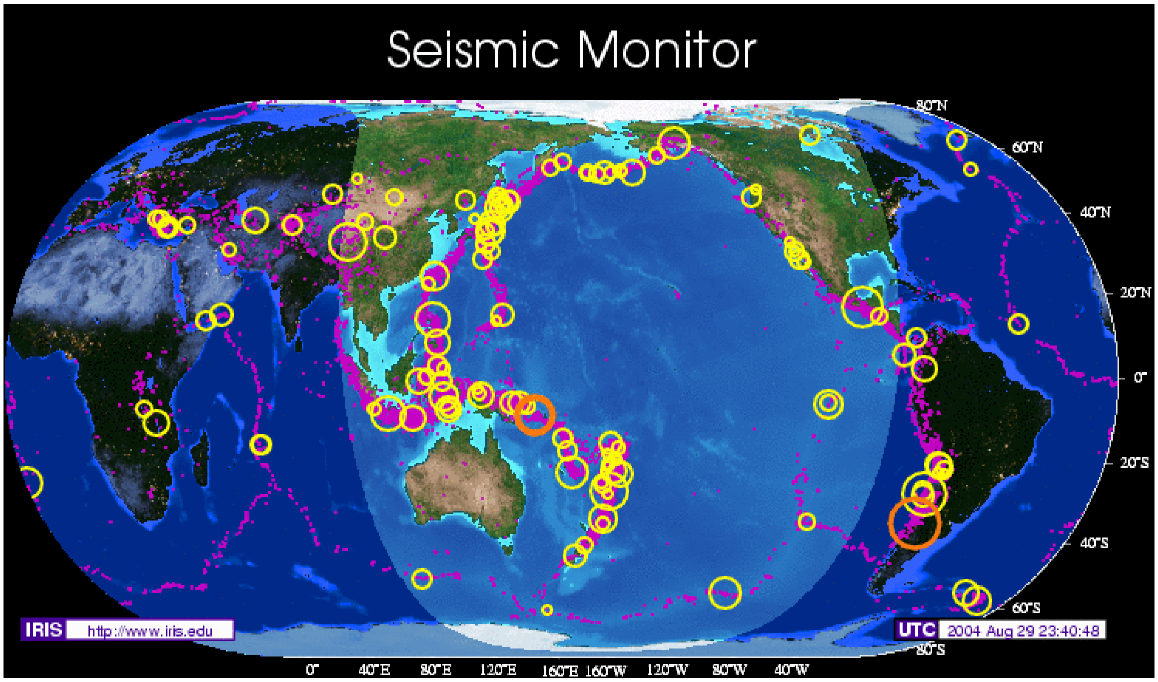
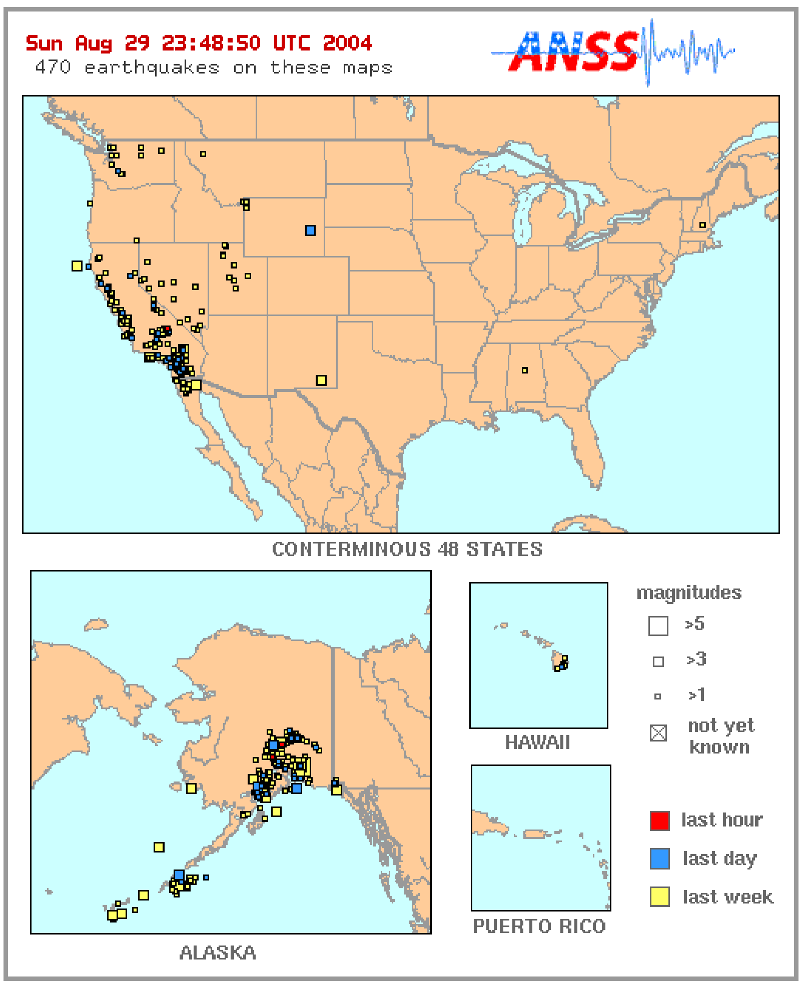
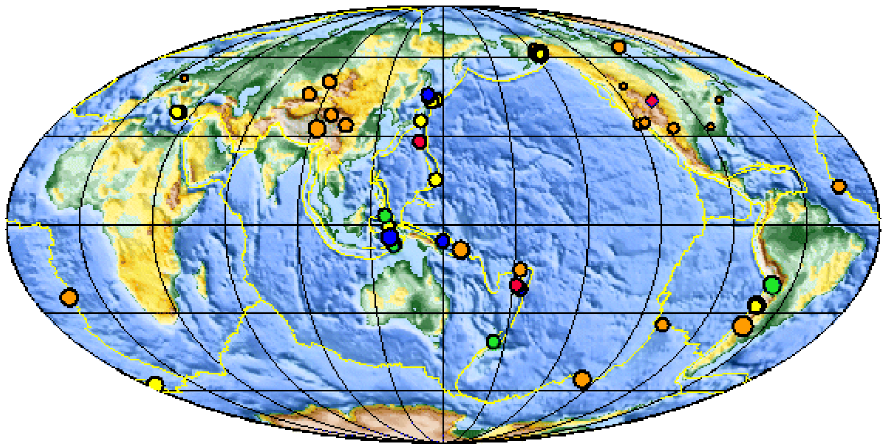
THE VIRTUAL TIMES
Recent Earthquakes & Active Volcanoes

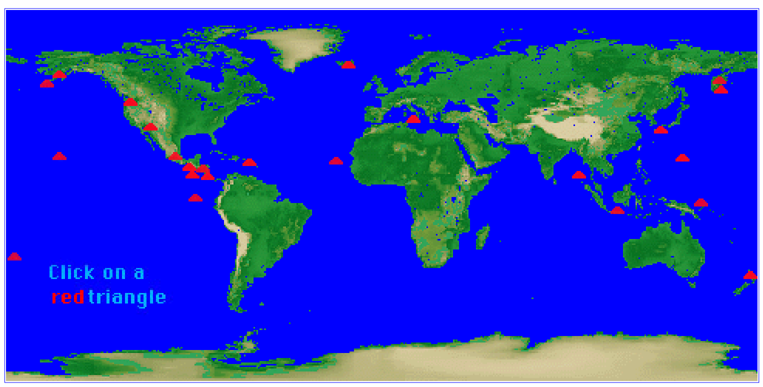
The Virtual Times: Weather Page

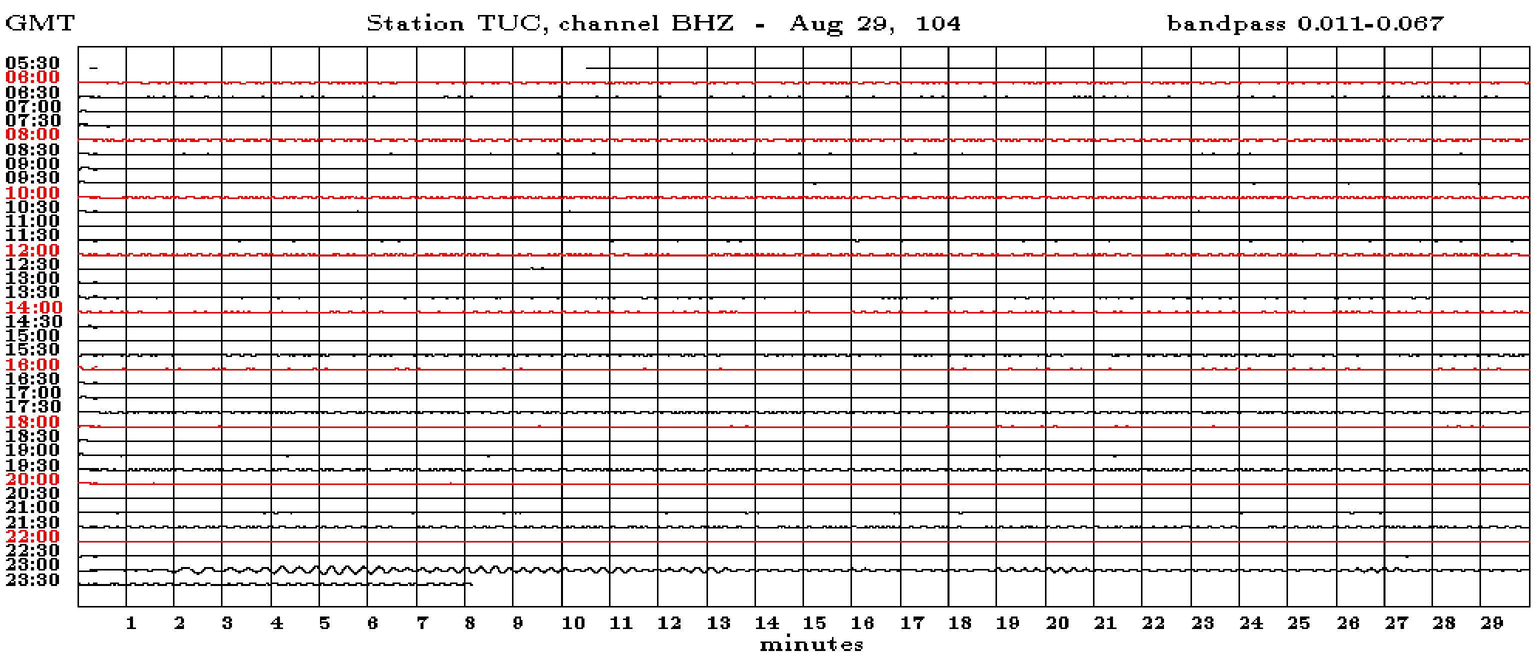






Active Volcanoes





Current long-period vertical seismic activity at station TUC, Tucson, Arizona

Seismic Data:

- Current Seismic Events
- Worldwide Seismic Stations

Interesting Maps and Images:

- Current world seismic activity maps
- Map of events between 1990-1996
- Earth's active volcanoes. . . . . many images and maps
- Animations, sounds and movies of volcanoes
- Images of volcanoes. . . . . by region, worldwide

Links to other Earthquake and Volcano sites:

- The New Madrid Earthquake . . . . .history, predictions and real-time seismograms
- World Wide Volcanism . . . . links to more specialized information on volcanoes
- Extensive links to seismic resources
- Volcanoes of the World
- Current Volcanic Activity and Super Volcanoes
- Volcano World

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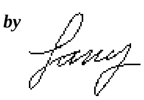

Let's Make Waves

Science Activity

Background
Many children hold misconceptions about the nature of water waves. One common misconception is that waves are generated from within the water. Although that may appear to be true, most waves -- and certainly the waves most children see -- are actually generated by wind. As wind travels across the water's surface, it pushes against the water and energy in the wind is absorbed by the water.

Another common misconception is that as a wave moves the water itself moves with the wave. In fact, a wave is the movement of energy through water. The water moves up and down, but not sideways in the direction of the wave's motion. The energy from wind moves in the direction of the wind. The energy moves from water molecule to water molecule, making each molecule move in a small circle. When one molecule bangs into its neighboring molecule, energy transfers to that neighboring molecule.

The most effective way to help children replace a misconception is to give them an experience that directly challenges it. In this simple set of activities children use wind to create waves and use marbles to model energy moving through water.

WHAT YOU'LL NEED

- 1 large, flat pan, about 4 or 5 inches deep, for each group (dishpans or larger)
- 1 electric table fan or paper fan for each group
- buckets or jugs for filling the pans with water
- food dye (optional)
- 5 large marbles or ball bearings for each group

WHAT TO DO

1. Ask the class what causes waves. Discuss their ideas.
2. Put the pans on tables and fill each pan with 2-3 inches of water.
3. Divide students into as many groups as you have pans and put each group around a pan.
4. About 1 foot from each pan (on a narrow side), place an electric fan or have a student hold a paper fan facing the pan.
5. Ask students to predict what will happen when the fan blows across the water's surface. After students have made predictions, let each fan blow at a low speed.
6. Have students report the results. Were there waves? Did the water bunch up at the far end of the pan? Did the water slosh out of the pan? Then speed up the fans and have students report again. Make sure students don't run fans so quickly that water sloshes out of the pans. (It might slosh out with the fan at high speed because the energy in the waves can't transfer into the pan's wall readily.)

7. Discuss with the class the connection between the wind and the waves. Ask students to guess why the water didn't bunch up at the far end of each pan.
8. Give each group a set of 5 marbles. Have students place 4 of the marbles on a table, lined up in a row with each marble touching its neighbors. Ask students to predict what will happen if the fifth marble is gently rolled at the marble at one end of the row. After students have made predictions, have one student in each group roll the fifth marble. The marble at the far end of the row will roll away and the others will not move. Have students repeat the experiment several times.
9. Discuss the idea that the energy in the rolling marble went into the marble it hit, and from that marble to the next, until the energy reached the last marble. The energy made that marble roll away. Wave energy moves through water the same way.
10. Bring the students together for a wrap-up discussion. Ask them what causes waves. Discuss their answers, relating the answers to the wave experiment. Ask them if water moves sideways inside a wave, or if the water stays in one place while the wave moves through it. Discuss the answers, relating the answers to the wave experiment and to the marble experiment.

Monster Waves

Science/Math Activity

In this activity, students will build a tabletop village and use it to visualize the relative height and affects of gigantic waves called tsunamis.

WHAT YOU NEED

- Tremors Behind Tsunamis (print and copy)
- A map of the world
- Small cardboard gift boxes or oak tag
- Construction paper
- Tape or glue
- Colored markers

WHAT TO DO

1. Read Tremors Behind Tsunamis to give students background on tsunamis and where they are likely to occur. Some students may to wish look in additional sources for more information on the topic.
2. Explain to students that the class will be making a replica of a seaside fishing village or port city to help them visualize the massive size of tsunamis and the destruction they can cause.
3. Divide students into small groups, having each group build a different section of the village or city. Encourage students to decide, as a class, which group will make buildings, land area, tsunami, etc.
4. Suggest that students make some buildings more than one story high. Later the class can decide how high a story would be in actual height.
5. When groups are done, have them assemble the village or city. Before placing the tsunami, they should speculate how high a tsunami wave would reach in the model.
6. Have students use the model to discuss what the tsunami would do to the village or city, the affect on the people who live there, and what could be done to prepare for future tsunamis.

TEACHING OPTIONS

- Have students write a newspaper article giving geographic reasons why your community would probably never experience a tsunami or might experience one.
- Traditional Japanese ideas about the source of gigantic waves that periodically come ashore and wreck Japanese coastal villages are found in the book *The Big Wave* by Pearl S. Buck. Have students read the book and discuss what the villagers believed caused the big wave. Encourage them to support their ideas with quotes that explain the attitudes of the villagers toward the overwhelming catastrophes they experienced from killer waves from the sea.

Activity Search | Reading Center | Math Center | Social Studies Center

Emergency Calls	Personal Safety	Weather Forecast	Road Conditions	Driving Alerts	Ferry Reports	Health Alerts	Fire Danger
Power Supply	Air Quality	Water Supply	Marine Weather	Travel Advisory	First Aid Training	Worker Safety	Boating Safety

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- About this Web Site

Provincial Emergency Program

Feedback

We welcome your questions or comments.

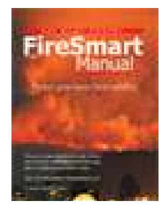
Key Information Links

NEW Current Wildfire Information NEW

- **Earthquake Hazard**
- **Drought Conditions**
- **Avian Influenza**
- **West Nile Virus**

NEW Landslides NEW

FireSmart Manual



A new publication to help BC homeowners take preventative steps to reduce the risk of wildfire to themselves and their neighbours. The manual includes a Firesmart homeowner assessment test. Click here.

• Top

Volunteer Recognition

Volunteers are at the heart of the emergency program's success. There are more than 13,000 volunteers across the province. They do everything from leading ground searches and helping the victims of serious car accidents to setting up networks of volunteer teams and coordinating emergency social services. Volunteers are men and women from all walks of life, spanning generations. To find out more, click here.

OVERBC, an umbrella organization of numerous non-profit service agencies, is in place to help communities recover from disasters with rebuilding of homes, clean-up, counselling, advocacy, and other services. To find out more, click here.

• Top

Disaster Resilient Communities Initiative

The mission of the Disaster Resilient Communities Initiative (DRCI) is to promote disaster resilient communities by providing tools to assist communities to manage risks from major emergencies and disasters.

To access a complete step-by-step hazard, risk and vulnerability analysis (HRVA) tool kit click on the image.

From A Distance

Due to a redesign of the ***From A Distance*** Web site,
URLs for individual pages have changed.

In 10 seconds, your browser will be redirected
to the new ***From A Distance*** Web site.
From there, you can use the search function
to find the page you are seeking.

Click here to go to the new From A Distance site now

TSUNAMI THE BIG WAVE

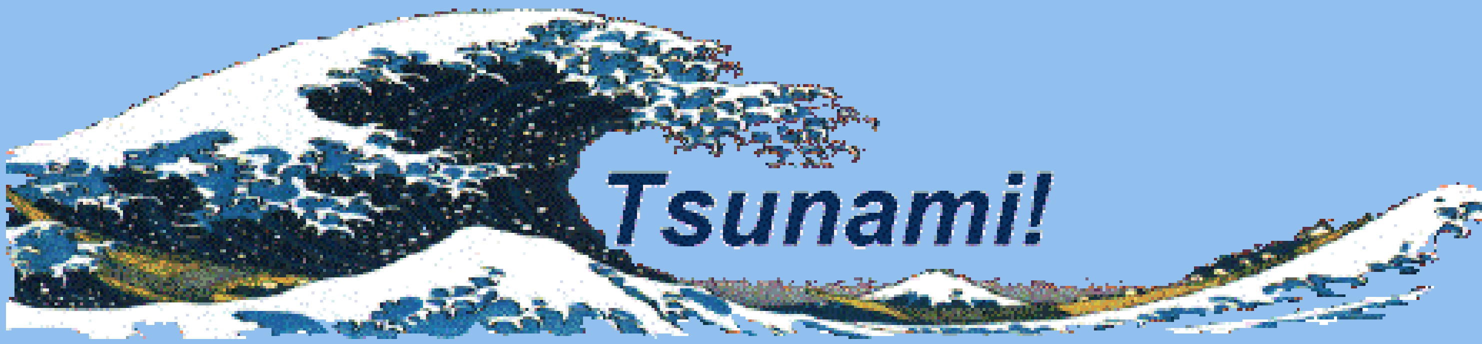
April Fools' Day 1946. A day for tricks and fun everywhere...everywhere but Hilo, Hawaii, that is. It was 7:00 a.m. and as the fishermen were getting the last of their early morning catch, the sea decided to play a trick on them. Suddenly the ocean rushed out, leaving fish and boats stranded on bare sand. The fishermen, quite aware of the impending danger, rushed to shore to warn the town of the approaching disaster.

On July 10, 1958, an earthquake triggered a landslide, which created a wave that wiped out trees 1,700 feet up a hillside on the opposite side of Lituya Bay, Alaska.

Within minutes a wave that had traveled 2,500 miles from the Aleutian Islands in Alaska came crashing into Hilo. It killed one hundred fifty-nine people and caused millions of dollars in damages. The wave that destroyed Hilo is one of the most powerful and most feared natural disasters of all: the tsunami!

[Exit] [Next]

HOME



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General Tsunami Information

Tsunami Survey and Research Information

Miscellaneous Information

- This site has recieved several awards for its content including:
  - **Ranebow Award**
    - a site dedicated to "Citing the best on the net"
  - **Web Book Award**

        - an award for sites that demonstrate an excellence in content
    - **Times Pick Award**
        - an award for sites that are new, useful, interesting and believed to be of real value to the visitors of the L.A. Times web site.
    - **Web Feet Seal of Approval**
        - an award award for outstanding sites in their subject area

Background on the Development of *Tsunami!*

- Acknowledgments : The people and organizations who have made this project possible
- Motivation : The impetus for this project
- Design : Document design considerations

Help

Tsunami: the Great Waves

Presented by

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Intergovernmerntal Oceanographic Commission
International Tsunami Information Center

The purpose of this brochure is to increase awareness and knowledge of tsunamis. Please share what you learn; knowing the right information may save your life and the lives of those you love.

The phenomenon we call "tsunami" (soo-NAH-mee) is a series of traveling ocean waves of extremely long length generated by disturbances associated primarily with earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis. In the deep ocean, their length from wave crest to wave crest may be a hundred miles or more but with a wave height of only a few feet or less. They cannot be felt aboard ships nor can they be seen from the air in the open ocean. In deep water, the waves may reach speeds exceeding 500 miles per hour.

Tsunamis are a threat to life and property to anyone living near the ocean. For example, in 1992 and 1993 over 2,000 people were killed by tsunamis occurring in Nicaragua, Indonesia and Japan. Property damage was nearly one billion dollars. The 1960 Chile Earthquake generated a Pacific-wide tsunami that caused widespread death and destruction in Chile, Hawaii, Japan and other areas in the Pacific. Large tsunamis have been known to rise over 100 feet, while tsunamis 10 to 20 feet high can be very destructive and cause many deaths and injuries.

The Tsunami Warning System (TWS) in the Pacific, comprised of 26 participating international Member States, monitors seismological and tidal stations throughout the Pacific Basin. The System evaluates potentially tsunamigenic earthquakes and disseminates tsunami warning information. The Pacific Tsunami Warning Center (PTWC) is the operational center of the Pacific

TWS. Located in Honolulu, Hawaii, PTWC provides tsunami warning information to national authorities in the Pacific Basin.

Learn more about Tsunamis:

What Cause Tsunamis?

Tsunamis on the Move

How We Save Lives

Warnings Dissemination and Research Activities

What You Should Do

ACKNOWLEDGMENTS THE PREPARATION OF THIS BROCHURE WAS SUPPORTED BY:

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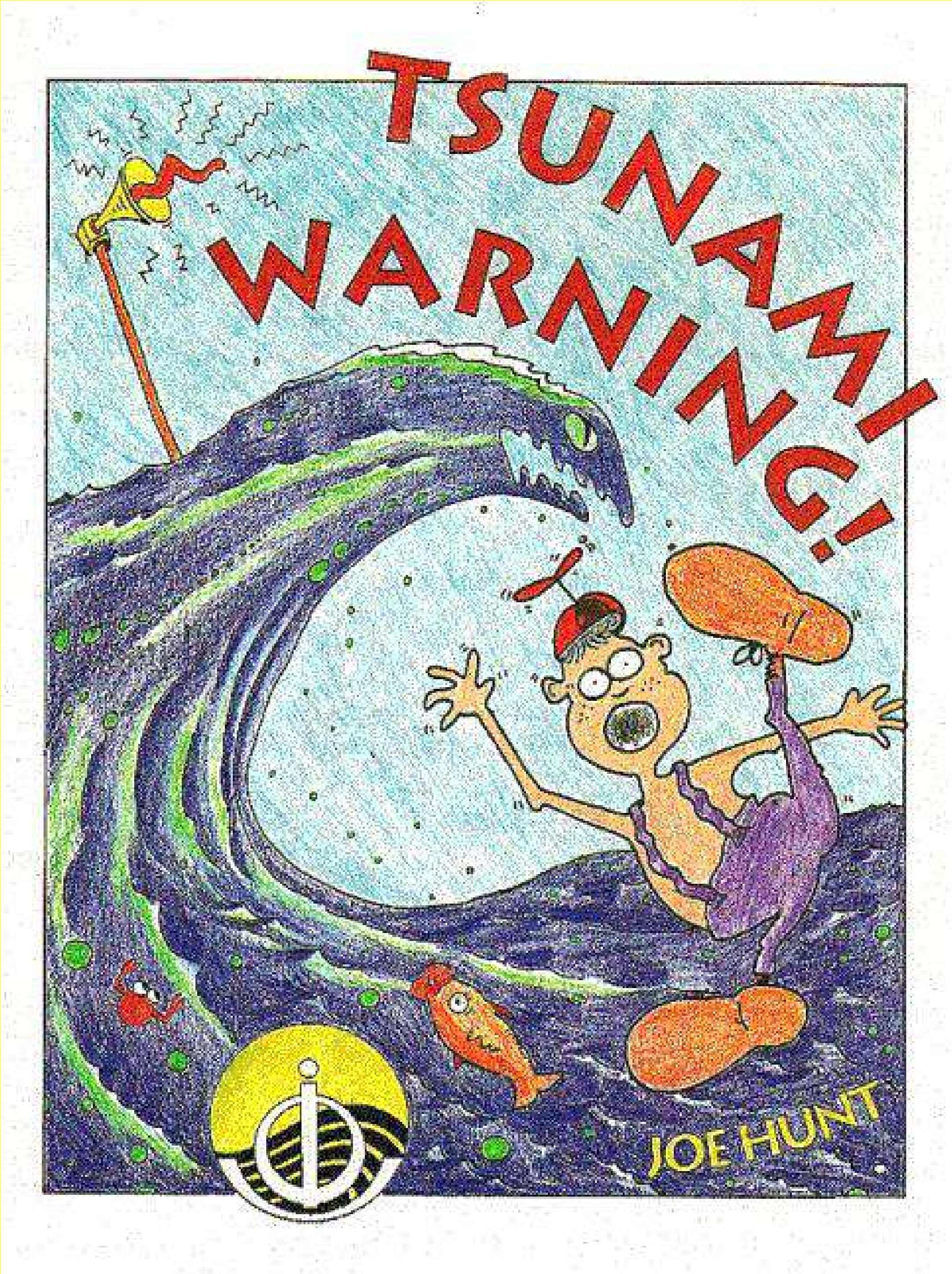
Questions or comments: melody.magnus@noaa.gov



Back **Next**

This book was written by Dr. Geroge Pararas-Carayannis, Ms. Patricia Wilson and Mr. Richard Sillcox. The illustrations were created by Mr. Joe Hunt. The web version was created by David Gronbeck-Jones, British Columbia Provincial Emergency Program, on behalf of the Western States Seismic Policy Council (WSSPC).

This book came from The West Coast & Alaska Tsunami Warning Center .

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WAVES OF DESTRUCTION: TSUNAMIS

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Surf's Up!

Hell's Crust: Our Everchanging Planet

The Restless Planet: Earthquakes

Out of the Inferno: Volcanoes

Waves of Destruction: Tsunamis

Surf's Up!

by Daniel Pendick

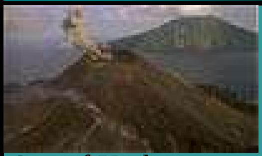
Though it's true that tsunamis are ocean waves, calling them by the same name as the ordinary wind-driven variety is a bit like referring to firecrackers and atomic warheads both as "explosives." Triggered by volcanic eruptions, landslides, earthquakes, and even impacts by asteroids or comets, a tsunami represents a vast volume of seawater in motion -- the source of its destructive power.

The Japanese characters for tsunami mean "harbor wave," and many people commonly refer to them as tidal waves, but in reality tsunamis have little to do with tides. They are creatures of the open ocean, trains of giant waves that can travel for thousands of miles across the sea and still pack enough energy to smash towns and drown the unwary.

A tsunami generated in the Aleutian Islands struck Hawaii in 1946.

Toss a stone in a pond and you create a series of concentric ripples. A tsunami is just like those ripples, except the disturbance that sets them in motion is of a much greater magnitude. Undersea landslides and the collapse of oceanic islands into the sea make tsunamis. Volcanic eruptions can also do it. In fact, the most deadly tsunami in recorded history followed the eruption and virtual obliteration of Indonesia's Krakatoa Volcano in 1883. An estimated 36,000 people died as a result of the eruption, the majority of them from the tsunamis.

Click on picture below to see full-size image.



Son of Krakatoa.

Tsunami debris.

Impacts by comets or asteroids can also generate giant tsunamis. No one has actually witnessed such an event, except perhaps in films like DEEP IMPACT. But computer simulations show that the giant tsunamis unleashed by Hollywood special effects wizards -- large enough to swamp the Manhattan skyline -- are possible and have almost certainly happened in the distant past. Scientists at the Los Alamos National Laboratory in New Mexico calculated that if an asteroid three miles across hit the middle of the Atlantic Ocean, the tsunami would swamp the upper East Coast as far inland as the Appalachian Mountains and drown the coasts of France and Portugal.

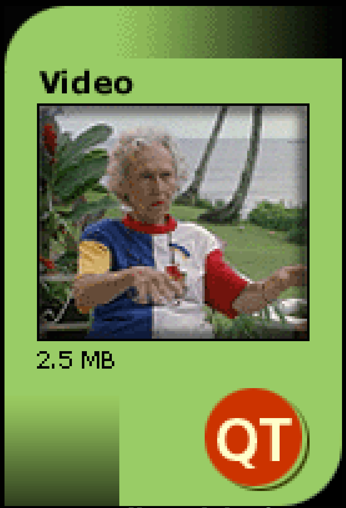
But by far the most frequent tsunami-maker is the buckling of the seafloor caused by an undersea earthquake. Tsunami earthquakes happen at subduction zones, places where drifting plates that make up Earth's outer shell, or lithosphere, converge, and the heavier oceanic plate dips below the lighter continents. There are subduction zones off Chile, Nicaragua, Mexico, and Indonesia that have generated killer tsunamis in the past decade. In the Pacific, there were 17 tsunamis from 1992 to 1996, and they took nearly 1,700 lives.

As a plate plunges down into Earth's interior, it moves in fits and starts -- sticking for awhile, then slipping. When it's stuck against the edge of a continental plate, stresses build up. When the locked zone gives way, parts of the seafloor may snap upward like a diver's springboard as the tension is released; other areas may sink downward. In the instant after the quake, the shape of the sea surface mirrors the contours of the seafloor below. But, just as quickly, gravity acts to return the sea surface to its original shape. As the rumpled sea flattens out, ripples race outward. A tsunami is born. (See Tsunami Attack animation, 17K. You will need the free Flash plug-in to view this animation.)

On the open ocean, tsunami waves approach speeds of 500 mph, almost fast enough to keep pace with a jetliner. But gazing out the window of a 747, you wouldn't be able to pick it out from the wind-driven swells. In deep water, the waves spread out and hunch down, with hundreds of miles between crests that may be just a few feet high. A passenger on a passing ship would scarcely detect their passing. But in fact the tsunami crest is just the very tip of a vast mass of water in motion. Though wind-driven waves and swells are confined to a shallow layer near the ocean surface, a tsunami extends thousands of feet deep into the ocean.

Because the momentum of the waves is so great, a tsunami can travel great distances with little loss of energy. The 1960 earthquake off the coast of Chile generated a tsunami that had enough force to kill 150 people in Japan after a journey of 22 hours and 10,000 miles. The waves from a trans-Pacific tsunami can reverberate back and forth across the ocean for days, making it jiggle like a planetary-scale pan of Jell-O.

As the waves in the tsunami reach shore, they slow down due to the shallowing sea floor, and the loss in speed is often accompanied by a dramatic increase in wave height. The waves scrunch together like the ribs of an accordion and heave upward. Depending on the geometry of the seafloor warping that first generated the waves, tsunami attacks can take different forms. In certain cases, the sea can seem at first to draw a breath and empty harbors, leaving fish flopping on the mud. This sometimes draws the curious to the shoreline and to their deaths, since the withdrawing of the sea is inevitably followed by the arrival of the crest of a tsunami wave. Tsunamis also flood in suddenly without warning. Tsunami waves usually don't curve over and break, like Hawaiian surf waves. Survivors of tsunami attacks describe them as dark "walls" of water. Impelled by the mass of water behind them, the waves bulldoze onto the shore and inundate the coast, snapping trees like twigs, toppling stone walls and lighthouses, and smashing houses and buildings into kindling.



You will need the free QuickTime (2.0 or above) plug-in to view this movie.
Tsunami survivor.

The contours of the seafloor and coastline have a profound influence on the height of the waves -- sometimes with surprising and dangerous results. During the 1993 tsunami attack on Okushiri, Japan, the wave "runup" on the coast averaged about 15 to 20 meters (50 - 65 feet). But in one particular spot, the waves pushed into a V-shaped valley open to the sea, concentrating the water in a tighter and tighter space. In the end, the water ran up to 32 meters (90 feet) above sea level, about the height of an 8-story office building.

Tsunami photo: Mrs. Harry A. Simms, Sr., courtesy of the U.S. Geological Survey.

Article: Surf's Up! | Sidebar One: Catching a Tsunami in the Act | Sidebar Two: Remembrance of Waves Past | ANIMATION
Hell's Crust: Our Everchanging Planet | The Restless Planet: Earthquakes
Out of the Inferno: Volcanoes | **Waves of Destruction: Tsunamis**

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National Weather Service
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- Tide Gauges
- TsunamiReady
- Links & References

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Click HERE for the Current Tsunami Information!

Click name for link to local Emergency Service Office:
Alaska, British Columbia, Washington, Oregon, California, or Hawaii

Virtual Earthquake Simulation.

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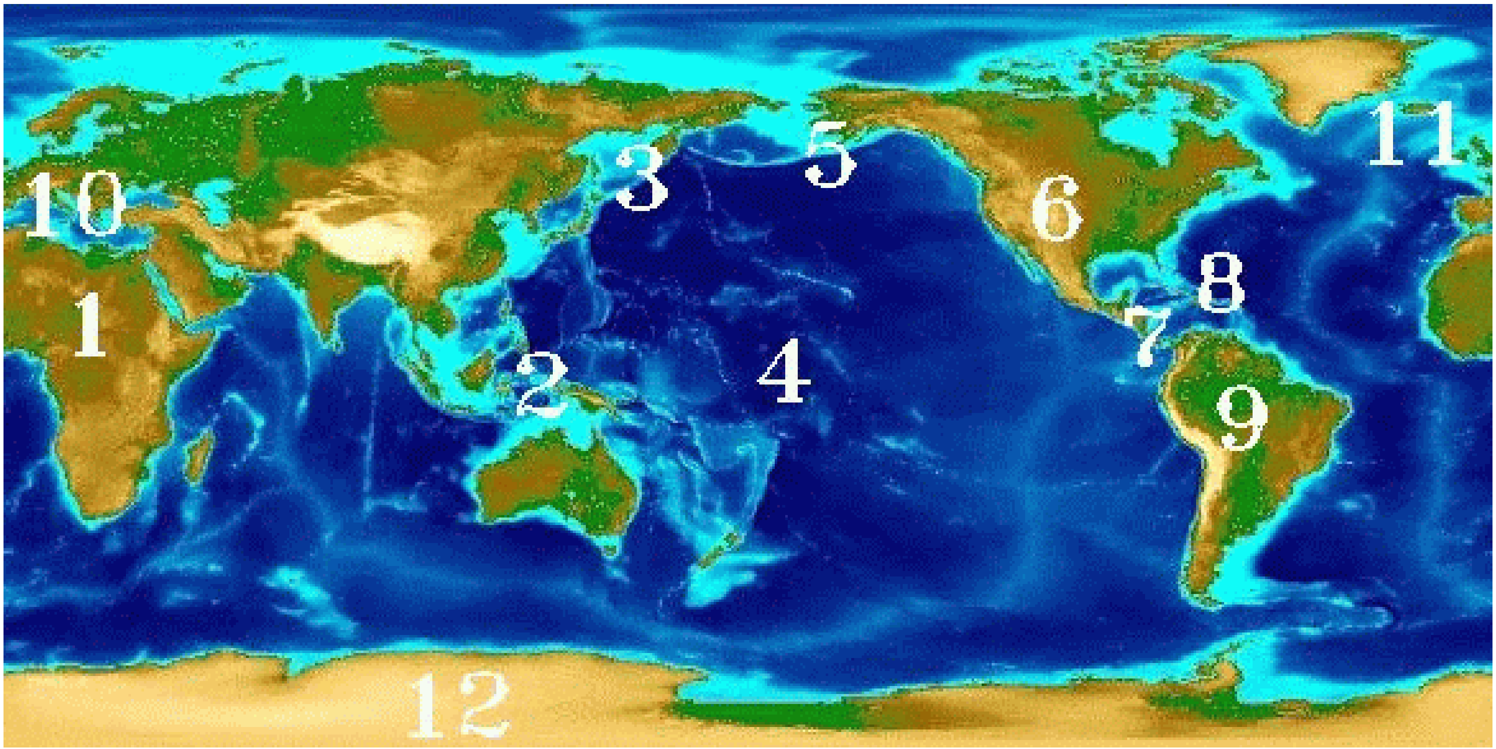
Earth's Active Volcanoes

by Geographic Region



1. **Africa and Surrounding Islands**
   - Fogo Caldera, SW Cape Verde Is. Atlantic Ocean
2. **Southwest Pacific, Southeast Asia, and India**
   - Merapi Volcano, Java, Indonesia
   - Batur Voclano, Bali, Indonesia
   - Rabaul Caldera, Papua New Guinea
   - Pinatubo Volcano, Central Luzon, Philippines
   - Mt Canlaon, Negros Islands, Philippines
   - Bulusan, Luzon, Philippines
   - Parker, Southern Mindanao, Philippines
   - Gemini Seamount, New Hebrides Island Arc, Vanuatu Islands
   - Aoba (Ambae Island), Vanuatu Islands
   - Barren Island, Andaman Islands, Indian Ocean, India
3. **East Asia (including Japan and Kamchatka)**

- Mt Unzen, Japan
- Bezymianny Volcano, Kamchatka, Russia
- Karymsky Volcano, Kamchatka, Russia
- Klyuchevskoi Volcano, Kamchatka, Russia
- Avachinsky Volcano, Kamchatka, Russia

4. Central Pacific and South Pacific, New Zealand

- Kilauea Volcano, Hawaii
- Kilauea Volcano, Hawaii
- Loihi Seamount, Hawaii
- Marianis Islands
- Metis Shoal, Tonga
- Ruapehu, New Zealand
- Taupo Volcanic Zone, New Zealand

5. Alaska and the Northern Pacific Region

- Akutan Volcano, Aleutian Islands
- Shishaldin Volcano, Aleutian Islands
- Mt Spurr, Alaska
- Pavlof Volcano, Alaska Peninsula
- Gorda Ridge, Northeast Pacific Ocean

6. North America

- United States
  - Mount St. Helens
  - Mount Lassen, California
  - Lake Superior Ice Volcanoes, Michigan
- Mexico
  - Popocatepetl, Mexico Archived Info
  - Popocatepetl, Mexico More recent

7. Central America

- Guatemala
  - Santa María Volcano, Guatemala
  - Pacaya Volcano, Guatemala
  - Fuego Volcano, Guatemala
  - Tacaná Volcano, Guatemala

        - Cerro Quemado Volcano, Guatemala
    - Costa Rica
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    - El Salvador
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        - Ilopango, El Salvador
        - Izalco, El Salvador
        - San Miguel, El Salvador
        - San Salvador, El Salvador
        - San Vicente, El Salvador
        - Santa Ana, El Salvador
    - Nicaragua
        - Cerro Negro, Nicaragua

8. **West Indies**
    - Soufriere Hills, Montserrat, West Indies
9. **South America and Surrounding Islands**
    - Galeras, Nevado Cumbal, Dona Juana, Cerro Negro de Mayasquer, Azufral
    - Galapagos, Fernandina
10. **Mediterranean**
    - Stromboli Volcano, Italy
        - Stromboli On-line
        - Dipartimento di Georisorse e Territorio at the Università degli Studi di Udine Stromboli project
        - Boris Behncke's Stromboli Pages
    - Etna Volcano, Italy
    - Current Etna Activity
    - Etna Volcano - Live Images
    - Clickable map of Sicilian Volcanoes
11. **North Atlantic, Iceland**
    - Bardarbunga/Grimsvotn Volcanoes
    - Askja Volcano
    - Krafla Volcano

- Hekla Volcano
- Katla Volcano
- Vestmannaeyjar Volcano

12. Antarctica

- Mount Erebus from the Mount Erebus Observatory

MTU Volcanoes Page

volcanoes@mtu.edu

Ujgok vulkonlami olamiga xus kelibsiz.

THE ELECTRONIC VOLCANO

Edited by:
Barbara DeFelice, Physical Sciences Librarian, Kresge Library,
D. Randall Spydell, Dept. of Earth Sciences
Richard E. Stoiber, Dept. Earth Sciences
Dartmouth College, Hanover NH 03755, USA

Mt St. Helens, from the U.S. Geological Survey Digital Data Series (DDS-8).

INTRODUCTION

The Electronic Volcano is a window into the world of information on active volcanoes. From here you can find many types of materials on active volcanoes worldwide, such as maps, photographs and full texts of dissertations and a few elusive documents. The Electronic Volcano will guide you to resources in libraries or resources on other information servers

THE ELECTRONIC VOLCANO -- Introductory material in Chinese
DER ELEKTRONISCHE VULKAN -- Introductory material in German
EL VOLCAN ELECTRONICO -- Introductory material in Spanish
IL VULCANO ELETTRONICO -- Introductory material in Italian
LE VOLCAN ELECTRONIQUE -- Introductory material in French
THE ELECTRONIC VOLCANO -- Introductory material in Russian

We are grateful to the many who have assisted us.

DEDICATION

The Electronic Volcano was created in memory of volcanologists, friends, from Colombia, France, Papua New Guinea, Russia, United Kingdom and United States of America who have died on volcanoes.

VOLCANO LISTSERV

Subscribe to the e-mail list VOLCANO%ASUACAD.BITNET to get updates on volcanic activitiy from observatories around the world. Researchers share lists of reprints of their articles on this e-list. Newsletters are posted, such as the Hawaii Volcano Watch and the Global Volcanism Newsletter. Some major journal publishers periodically list the contents of their journals here.

CONTENTS OF THE ELECTRONIC VOLCANO

The casual browser is invited to sample the Electronic Volcano:

See the picture by Katia Krafft Pele Dancing. Find out about the latest eruptions of the Mexcan volcano Popocatepetl. Read an eyewitness account of the birth of Paricutin Volcano in Mexico in 1943.

Benjamin Franklin may have been the first person to consider the effect of volcanic eruptions on weather. Read his 1784 paper.

See a volcanic eruption from under the sea as pictured on a postage stamp.

A. CATALOGS OF ACTIVE VOLCANOES

Valuable sources of descriptive information and references to the literature. Selected ones are listed; check with your library for availability.

B. DATASETS FOR LITERATURE CITATIONS RELATIVE TO ACTIVE VOLCANOES

C. ELECTRONIC VERSIONS OF TEXT MATERIAL

Includes a few of the more elusive items relative to active volcanoes. Listed by author, title, subject

D. JOURNALS WHICH INCLUDE ARTICLES ON ACTIVE VOLCANOES

A list of the major journals concentrating on volcanological research, not including journals such as Science and Nature that cover volcanism as well as many other topics. Some volcanological observatory bulletins are in this list. Each title has a list of libraries holding at least some issues. TABLES OF CONTENTS OF JOURNALS

E. VISUAL INFORMATION

Photo, radar, videotape and cinematic coverage of active volcanoes

F. MAPS OF ACTIVE VOLCANOES

Topographic Maps -- Geologic Maps -- Volcanic Hazard Maps

G. VOLCANIC OBSERVATORIES AND INSTITUTIONS

H. THESES RELATIVE TO ACTIVE VOLCANISM

Theses for which there are Abstracts and/or some excerpts. Listed by Author

I. VOLCANIC HAZARDS

J. CURRENT EVENTS AND RESEARCH

K. VOLCANO NAME & COUNTRY INDEX of those included in the ELECTRONIC VOLCANO

Frequent changes are being made in this document and particularly in those linked to it.

Last updated 28-Mar-1997. Many changes in the links are more recent.
Richard E. Stoiber & Barbara DeFelice & D. Randall Spydell

Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Manoa

Hawai'i Space Grant Consortium

Exploring Planets in the Classroom
Hands-on Activities

Volcanology Activity Index

- Gelatin Volcanoes: Teacher pages- **and -** Student pages
  To understand how and why magma moves inside volcanoes.

- Lava Layering: Teacher pages **- and -** Student pages
  To learn about the stratigraphy of lava flows produced by multiple eruptions.

- Cake Batter Lava: Teacher pages **- and -** Student pages
  To understand some of the geological processes and the structures that form as lava flows across planetary landscapes by using cake batter as an analog for lava.

- Piles of Fire: Teacher pages **- and -** Student pages
  To investigate how particle size affects the angle of a volcano's slope.

- Viscosity: Teacher pages **- and -** Student pages

To determine how fluid a liquid really is by measuring its viscosity.

Return to Hands-On Activities home page.

http://www.spacegrant.hawaii.edu/class_acts/

Hawai'i Space Grant Consortium

Communications: Linda Martel

Global Volcanism Program Home Page

Global Volcanism Program Home Page

Link to National Museum of Natural History Home Page

Worldwide Holocene Volcano and Eruption Information

- **Volcanoes of the World**
  - **Find a Volcano by Region**
    - **Mediterranean and W Asia**
    - **Africa and Red Sea**
    - **Middle East and Indian Ocean**
    - **New Zealand to Fiji**
    - **Melanesia and Australia**
    - **Indonesia**
    - **Philippines and SE Asia**
    - **Japan, Taiwan, Marianas**
    - **Kuril Islands**
    - **Kamchatka and Mainland Asia**
    - **Alaska**
    - **Canada and Western USA**
    - **Hawaii and Pacific Ocean**
    - **México and Central America**
    - **South America**

- West Indies
- Iceland and Arctic Ocean
- Atlantic Ocean
- Antarctica

- Find a Volcano by Name
- Find a Volcano by Eruption Date
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- One-line Summaries
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- About Volcanoes of the World

- **Volcanic Activity Reports**
  - Bulletin of the Global Volcanism Network
  - SI / USGS Weekly Volcanic Activity Report
  - Preliminary Notices of Volcanic Activity
  - Volcano Listserv Messages
  - About Volcanic Activity Reports

- **Frequently Asked Questions**
  - What is a volcano?
  - What is an eruption?
  - How many active volcanoes are there in the world?
  - What is the world's highest volcano?
  - How long does an eruption last?
  - Has volcanic activity been increasing?
  - About Frequently Asked Questions
- **Information**
  - Products
    - Volcanoes of Mexico (CD)
    - Earthquakes and Eruptions (CD)
    - Volcanoes of Indonesia (CD)
    - This Dynamic Planet (map)
    - Parícutin: The Volcano Born in a Mexican Cornfield (book)
    - Global Volcanism 1975-1985 (book)
    - Bulletin of the Global Volcanism Network (newsletter)
  - Staff and Volunteers
  - Volcanology Links
  - Search Options
  - About the Global Volcanism Program
  - About Volcanoes of the World
  - About Volcanic Activity Reports

- **About Frequently Asked Questions**

NEWS: The GVP website has a whole new look (as of 25 May 2004), including a menu-driven navigation system! New features include a photo gallery of volcano types and volcanic processes, the Weekly Reports being integrated with the other volcano information, and faster-loading regional volcano listings with thumbnail images. The database is current through 2003, and over 1,000 volcano photographs are available.

Quick Volcano Search

Name:

Region: 00 - World

Sort by: Names Geography

Find: Volcano Synonyms & Subfeatures

Get Volcano Names

Quetrupillan
Central Chile

The Smithsonian's Global Volcanism Program seeks better understanding of all volcanoes through documenting their eruptions — small as well as large — during the past 10,000 years.

Contact:

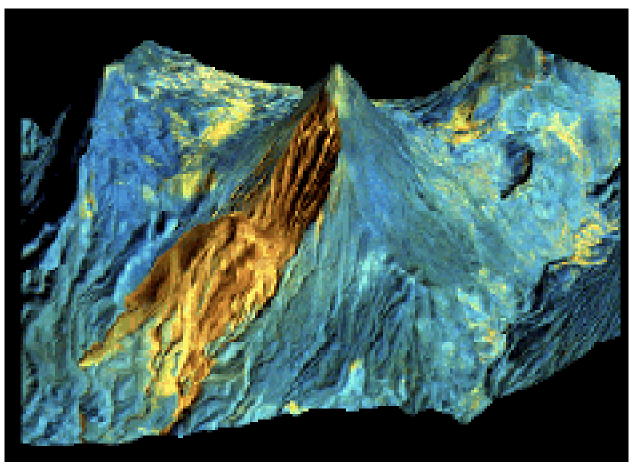
Valid XHTML 1.0! Valid CSS! Accessible Website Menu This site is XHTML and CSS compliant. It is best viewed with a standards-compliant browser (typically version 6 or higher), but should be useable with any browser.

Global Volcanism Program, Department of Mineral Sciences, National Museum of Natural History - Room E-421, MRC 0119, PO Box 37012, Smithsonian Institution, Washington DC 20013-7012

Welcome to the Michigan Technological University Volcanoes Page

Sponsored by the Keweenaw Volcano Observatory.
Michigan Tech

Houghton, MI USA



Our Purpose:

A primary focus of volcanology is to provide scientific and educational information that can lead to hazard mitigation. **Michigan Tech's Volcanoes Page** aims to provide information about volcanoes to the public and to complement other informational sites on the web. We started this site when there were almost no other volcano sites--now there are lots, and many of them have far more resources. So we now aim to fill in spots that aren't covered elsewhere. Send your suggestions!

What is a volcano?

We could say a volcano is a liquid rock plumbing system which extends from several 10's of kilometers depth to the earth's surface, and includes the near vent deposits of eruptions. Is this a good definition? Is this a volcano? How about this? Or this?

Earth's Volcanoes

What's happening now? --Smithsonian/USGS Weekly reports

Which are earth's active volcanoes?--Smithsonian Global Volcanism Network

Details of recent activity--GVN Monthly Bulletin

How Volcanoes Work --NASA SDSU

Useful links by volcano---USGS-CVO

Volcanoes of Canada --Pacific Division, Geological Survey of Canada

Volcano World individual volcano links--VW-NoDakota

Volcanic Hazards Mitigation

Volcanic Cloud Hazards to Aviation - This page aims to provide information about how volcanic ash clouds affect aircraft, and how to avoid this hazard.

Volcanoes and People Scientists are not communication experts. This page is a first step at building communcation between scientists and teachers, with a goal of mitigating natural hazards.

Basic Guide to Volcanic Hazards prepared by Colleen M. Riley, MTU Volcanoes are beneficial to humans living on or near them. They produce fertile soil, and provide valuable minerals, water reservoirs, geothermal resources, and scenic beauty. But volcanoes can be very dangerous. Where can a person go to be safe from an erupting volcano? What types of volcanic hazards might they face? These questions are difficult to answer because there are many types of volcanic eruptions which produce different types of volcanic hazards.

IAVCEI web site Safety at volcanoes is a major concern--before you go to a volcano, read the safety recommendations from IAVCEI!

Granular Volcano Group Sebastien Dartevelle's work.

Air and Health-- European Environment Agency

NEW! Peace Corps Master's program in Mitigation of Geological Natural Hazards--first program of its kind, and a way to combine an MS degree with real experience on the rim of fire.

Simulating a volcanic crisis in the classroom--Colgate Univ

GVES Vesuvius, The Making of a Catastrophe

Central American Volcanoes

Volcanoes of Northern Central America Northern Central America includes Guatemala and El Salvador. It is a region of high population density and with many active volcanoes. Here we have tried to provide some data of hazard mitigation value about this region.

Carr's Web--Rutgers University An introduction of Central American Volcanoes for researchers.

Honduras Geology--great resource from Rob Rogers, Univ of Texas

Ceren Web Resource--Joya de Ceren, El Salvador Univ Colorado--Payson Sheets

Salvadoran Volcanoes--SNET, El Salvador

Guatemalan Volcanoes--INSIVUMEH-Guatemala

Volcanoes of Nicaragua--INETER-Nicaragua

Casita Volcanic landslide, 1998 USGS-Kevin Scott

Latin American Volcanoes---Glyn Williams-Jones

Remote Sensing of Volcanoes

USGS Volcanic Hazards--Satellite methods What satellite data is used, and how it is used to tell us about activity.

Satellite Detection of eruptions Satellite sensors around the world are used to keep track of volcanic activity--you can consult the near realtime and not so near realtime sources.

Volcanic Clouds Page--The Volcanic Clouds Web Site describes the formation and composition of volcanic ash, gas and aerosol clouds, the remote sensing methods we use to study them, and ways that this information can be used for science and hazard mitigation.

Natural Hazards from Space--NASA Earth Observatory site

Earth's Volcanoes--JPL Site

Remote Sensing Tutorial--NASA Goddard

Astronaut Photos of Earth--NASA JSC

Remote Sensing in Natural Hazards--Univ of Washington

Online Journals Related to Volcanology

Where volcanologic research is published--updated 18 May 2001

Other www sites of volcanic interest

Links to items related to volcanoes, including observatories, universities with volcano research and other items of interest to volcanophiles.

Foreign Volcano Maps--USGS CVO

Erta Ale from Stromboli

IAVCEI Commision for Volcanic Gases

Recent Michigan Tech Publications about volcanoes

How Volcanoes Work, SDSU site

PBS Nova program about Galeras and Long period seismic warnings

Volcanic Humor

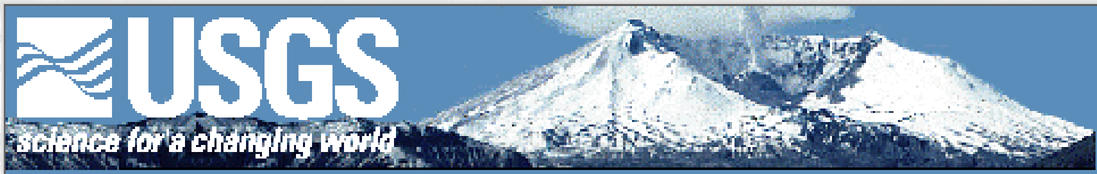
A lighter side to living with volcanoes.

How to cook with lava

Information for future volcanologists--USGS/Cascade Volcano Observatory

Go to the MTU GES Home Page

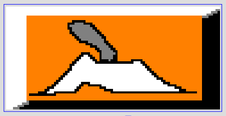
raman@mtu.edu



Cascades Volcano Observatory

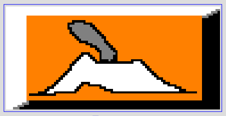
USGS Home	Geology	Water	VHP	AVO	HVO	LVO	YVO	Contact Us	Search Our Site	Site Map

Special Features



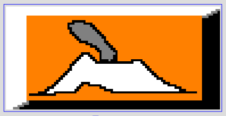
News and Current Events

-- CVO Talks and Presentations - Cascade Range Updates - Mount St. Helens Updates - World-Wide Volcanoes in the News - Links to Current Volcanic Activity



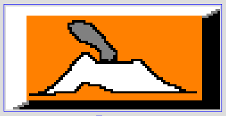
Cascade Range Current Activity Updates

-- Current Status of the Cascade Range Volcanoes



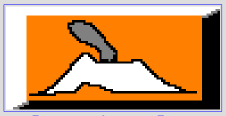
Cascade Range Volcanoes Summary

-- Interactive table, Cascades Volcanoes with links to new publications, current information, photos, maps, links, plus brief eruptive history of each volcano



Hazards Assessment Reports and Maps

-- Latest Hazards Assessment Reports and Maps (in PDF) for various volcanoes in the Cascade Range



Educational Outreach

-- Learn about Volcanoes - FAQ's - Terminology - Read About Volcanoes - Become a Volcanologist - Activities and

CVO Information

- NEW on this server
- CVO Office Information -- *Who We Are and What We Do*
- Use of CVO Materials
- Site Map
- **2004 Jack Kleinman Internship -- Recipients Announced !!!**

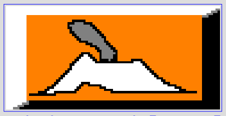
Volcanoes

- Volcanoes
- Mount St. Helens
- Cascade Range
- Visit a Volcano
- Learn About Volcanoes -- *FAQ's*
- Photo Archives

Menus of Interest

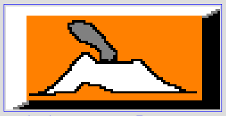
- Glossary of Hazards, Features, and Terminology
- Hazards
- Hazards Assessment Reports and Maps
- Hydrology
- Living With Volcanoes
- Maps and Graphics
- Monitoring
- Outreach
- "Real-Time" Monitoring
- Photo Archives
- Projects and Research

"Fun Stuff" - Videos and Posters - "Pictograms" - Teachers Packets and Aids - Educational Links, etc.



[Living With Volcanoes]

-- America's Volcanic Past - The "Plus Side" of Volcanoes - Historical, Cultural, and Economic Side of Volcanoes - "VolcanoCams" - Volcanoes in the Movies - What to do if a Volcano Erupts, etc.



Visit a Volcano

-- Information and Maps to the Cascade Range - Travel and Hiking Information - Links to other Agencies - National Parks, Volcanic Monuments, and National Forests - Tourism and Lodging - America's Volcanic Past - Armchair Tours of the Cascade Volcanoes - Climb A Volcano, etc.

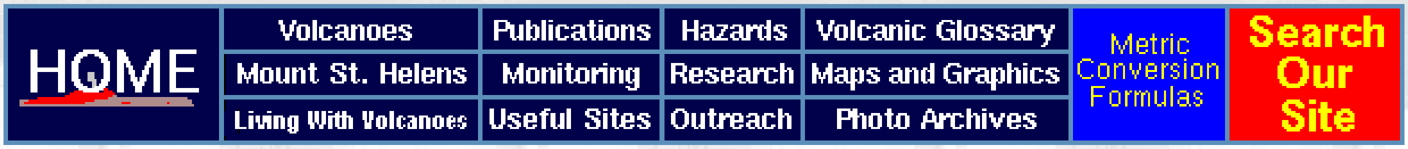
- Publications and Reports
- VDAP - Volcano Disaster Assistance Program
- VHP - Volcano Hazards Program
- Volcano Observatories

Miscellaneous

- USGS -- *Public Website Links*
- Miscellaneous -- *Geologic Time Scale, Metric Conversions, RGB to Hex, Time Zones, MORE*
- Search the Internet -- *Common Search Engines*
- Useful Links and "Just Neat Stuff" -- *Airlines, Maps, Weather, Roads, Travel -- PLUS lots and lots of Useful Links, Programs, and Useful Things such as Dictionaries, Zip Codes, Airlines, Post Office, and MORE*
- How-To-Order USGS Reports, Maps, Aerial Photographs, etc.

USGS Volcano Hazards Program Links

- VHP - Volcano Hazards Program Website
- AVO - Alaska Volcano Observatory Website
- CVO - Cascades Volcano Observatory Office Information
- HVO - Hawaiian Volcano Observatory Website
- LVO - Long Valley Observatory Website
- YVO - Yellowstone Volcano Observatory Website



U.S. Department of the Interior, U.S. Geological Survey
Cascades Volcano Observatory, Vancouver, Wa
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Monitoring Active Volcanoes

On-Line Edition

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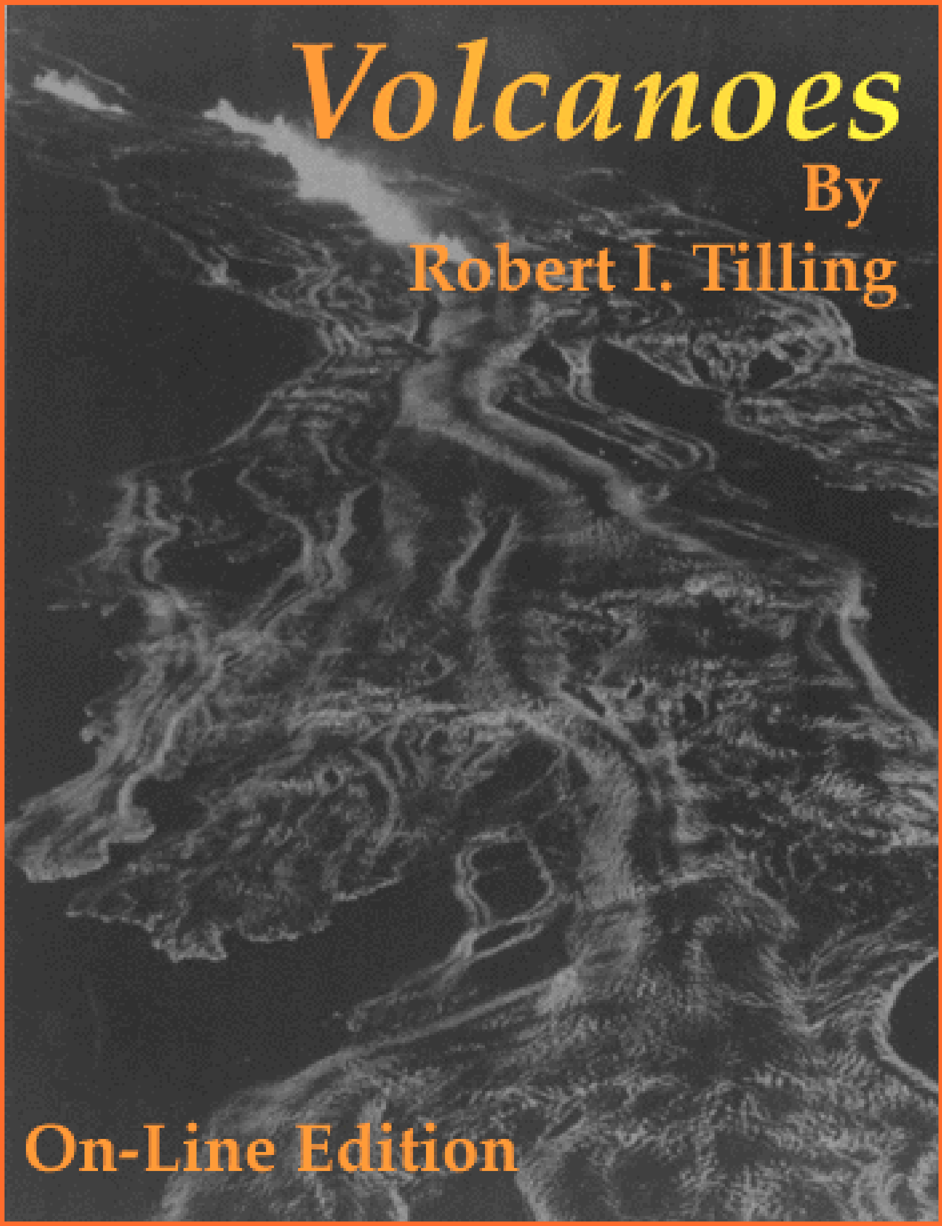

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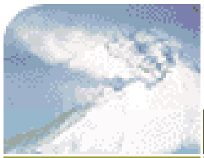
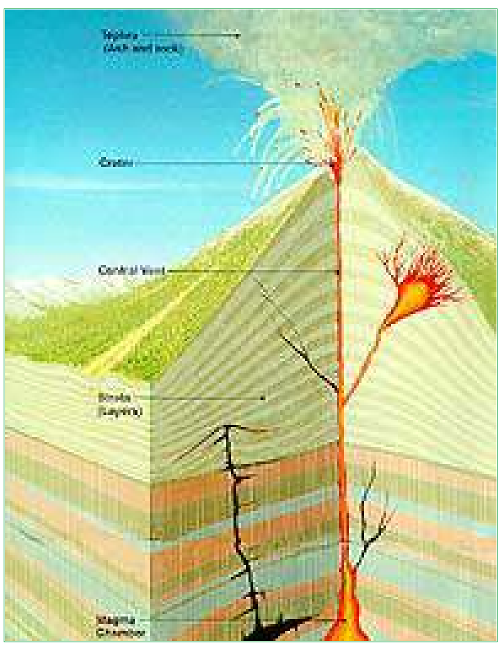


VOLCANOES!

Introduction (grades 4 - 8)

*This packet is only available online.
(From VOLCANOES! Poster. All the images are clickable for larger view.)



(Left: Poster Fig. 1)

Volcanic eruptions are among the Earth's most powerful and destructive forces. Imagine hearing a volcano erupt thousands of miles away. Imagine looking through binoculars and seeing the top of a mountain collapse. Imagine discovering an ancient Roman city that had been buried in volcanic ash.

Volcanoes are also creative forces. The Earth's first oceans and atmosphere formed from the gases given off by volcanoes. In turn, oceans and an atmosphere created the environment that made life possible on our planet. Volcanoes have also shaped the Earth's landscape. Many of our mountains, islands, and plains have been built by volcanic eruptions.

Why Do Volcanoes Erupt?

Deep within the Earth it is so hot that some rocks slowly melt and become a thick flowing substance called **magma**. Because it is lighter than the solid rock around it, magma rises and collects in magma chambers. Eventually some of the magma pushes through **vents** and **fissures** in the Earth's surface. A volcanic eruption occurs! Magma that has erupted is called **lava**.

Some volcanic eruptions are explosive and others are not. How explosive an eruption is depends on how runny or sticky the magma is. If magma is thin and runny, gases can escape easily from it. When this type of magma erupts, it flows out of the volcano. Lava flows rarely kill people, because they move slowly enough for people to get out of their way. Lava flows, however, can cause considerable destruction to buildings in their path.

If magma is thick and sticky, gases cannot escape easily. Pressure builds up until the gases escape violently and explode. In this type of eruption, the magma blasts into the

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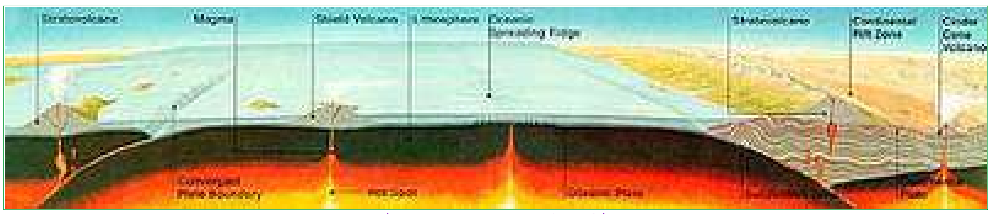
air and breaks apart into pieces called **tephra**. Tephra can range in size from tiny particles of **ash** to house-size boulders.

Explosive volcanic eruptions can be dangerous and deadly. They can blast out clouds of hot tephra from the side or top of a volcano. These fiery clouds race down mountainsides destroying almost everything in their path. Ash erupted into the sky falls back to Earth like powdery snow, but snow that won't melt. If thick enough, blankets of ash can suffocate plants, animals, and humans. When hot volcanic materials mix with water from streams or melted snow and ice, mudflows form. Mudflows have buried entire communities located near erupting volcanoes.

Because there may be hundreds or thousands of years between volcanic eruptions, people may not be aware of a volcano's dangers. When Mount St. Helens in the State of Washington erupted in 1980, it had not erupted for 123 years. Most people thought Mount St. Helens was a beautiful, peaceful mountain and not a dangerous volcano.

Where Do Volcanoes Erupt?



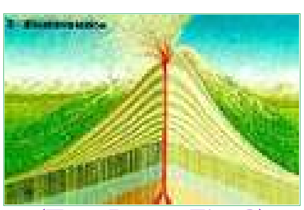
(Top: Poster Fig. 2)

Volcanoes occur because the Earth's **crust** is broken into plates that resemble a jigsaw puzzle. There are 16 major plates. These rigid plates float on a softer layer of rock in the Earth's **mantle**. As the plates move about they push together or pull apart. Most volcanoes occur near the edges of plates.

When plates push together, one plate slides beneath the other. This is a **subduction zone**. When the plunging plate gets deep enough inside the **mantle**, some of the rock on the overlying plate melts and forms magma that can move upward and erupt at the Earth's surface. At **rift zones**, plates are moving apart and magma comes to the surface and erupts. Some volcanoes occur in the middle of plates at areas called **hotspots** - places where magma melts through the plate and erupts.

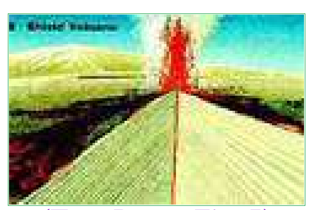
Why Do Volcanoes Grow?

Volcanoes grow because of repeated eruptions. There are three main kinds, or shapes, of volcanoes based on the type of materials they erupt.



(Top: Poster Fig. 3)

(Top: Poster Fig. 4)



(Top: Poster Fig. 5)

Explore These...
Earth Hazards
Water
Plants & Animals
Maps & Images
Rocks & Images
Real-time Info
Ecosystems
Natural Resources

Stratovolcanoes build from eruptions of lava and tephra that pile up in layers, or strata, much like layers of cake and frosting. These volcanoes form symmetrical cones with steep sides.

Cinder cones build from erupting lava that breaks into small pieces as it blasts into the air. As the lava pieces fall back to the ground, they cool and harden into cinders that pile up around the volcano's vent. Cinder cones are very small cone-shaped volcanoes.

Shield volcanoes form from eruptions of flowing lava. The lava spreads out and builds up volcanoes with broad, gently sloping sides. The shape resembles a warrior's shield.

Mount St. Helens!

On May 18, 1980, Mount St. Helens violently erupted. For 2 months the volcano showed signs that it was waking up from its 123-year sleep. Earthquakes beneath the mountain increased. Steam and ash erupted. And a "bulge" grew on the mountain's steep north side. All these warning signs signaled that magma was moving upward inside the volcano.

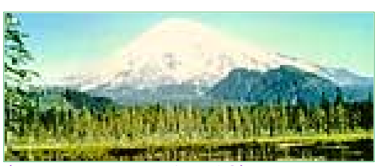
(Top: Poster Fig. 6, 7, 8, and 9)

The First 35 Seconds

On the morning of the eruption, Gary Rosenquist was camped about 36 kilometers (11 miles) from the summit of Mount St. Helens. Another camper was looking through binoculars and noticed that the upper right side of the volcano looked "fuzzy." He shouted that the "mountain was going." Rosenquist began taking photographs. An earthquake that occurred beneath the volcano shook loose the "bulge" on the mountain's steep north side. Rock and ice slide down the mountain. Then the mountain exploded gases, magma, and water laterally out the side where the "bulge" had been. The explosion hurled hot rock and ash at hurricane speeds. Ash and steam erupted vertically from the volcano's crater and continued for 9 hours.

The Mountain Blows its Top

Volcanic eruptions alter the surface of the Earth's **lithosphere**, the hard, outermost shell of the Earth.



(Top: Poster Fig. 10)

Many eruptions have built Mount St. Helens' beautiful cone shape. The May 18, 1980, eruption, however, dramatically changed the volcano's size and shape. It tore off the mountain's top and blasted a giant crater in its side.


(Top: Poster Fig. 11)

Smaller eruptions have continued since 1980. Mostly occurring on the bottom of the volcano's crater, each eruption squeezes up thick, pasty lava and sometimes spews out tephra. In photograph number 11, look for the dome that has formed inside the crater. Slowly, the volcano is rebuilding itself into its former shape.

Up in the Air


(Top: Poster Fig. 12)

Volcanoes erupt materials into the **atmosphere**, the gases and water vapor that surround the Earth.

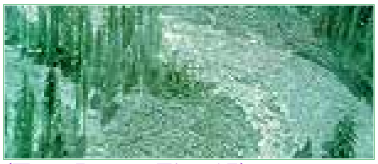

(Top: Poster Fig. 13)

The eruption blasted ash and gases into the atmosphere. Winds carried ash great distances. The ash-covered truck shown here was parked 19 kilometers (12 miles) from Mount St. Helens. Two men who were camped nearby died, suffocating from hot volcanic ash. They were two of 57 known fatalities.


(Top: Poster Fig. 14)

In Yakima, a city in eastern Washington, ash began to fall about an hour after the eruption. It became so dark that lights were turned on all day. Face masks were necessary when people went outside. It took 10 weeks to haul away the ash from Yakima's streets, sidewalks, and roofs.

Water, Rock, and Mud


(Top: Poster Fig. 15)

The **hydrosphere** - the liquid water on and under the Earth's surface - can make volcanic eruptions more dangerous.


(Top: Poster Fig. 16)

Before the May 18, 1980, eruption, the streams on Mount St. Helens were crystal clear. After the eruption, streams were choked with rock and mud. When water mixed with rock and mud, it created volcanic mudflows (also called lahars) that were able to move down the volcano's slopes. On the steepest slopes, the mudflows traveled up to 144 kilometers per hour (90 miles per hour). Some of the mudflows were as high as a six-storied building!

Fire and Ice


(Top: Poster Fig. 17)

Ice and snow - the part of the Earth system called the **cryosphere** - can melt during a volcanic eruption.


(Top: Poster Fig. 18)

Snow and ice-capped volcanoes like Mount St. Helens are especially dangerous if they erupt. Much of the water in Mount St. Helens' mudflows came from snow and ice melted by the heat of the eruption. These mudflows were as thick as wet cement and able to carry along almost anything that they picked up. Eyewitnesses reported seeing mudflows carry everything from farm animals to a fully loaded logging truck. Fortunately, when the mudlfow hit, no one was in the bus pictured here.

Death and Recovery

The Earth's **biosphere** - the realm of all living things - is affected during a volcanic eruption.


(Top: Poster Fig. 19)

The force of the eruption on Mount St. Helens blew down giant trees like they were match sticks. Almost all of the animals that lived in these forests were killed as well. Birds were particularly hard hit. Some birds survived the eruption but died later because the insects and plants they ate had died.


(Top: Poster Fig. 20)

Surprisingly, some plants and animals did survive. Plants sprouted from roots that survived even though the plants' tops had been sheared off. Animals such as gophers and ants survived in their underground homes. Within a few weeks of the eruption deer, elk, and other animals moved in from nearby areas to take advantage of the new plants that were sprouting.

Further Reading

- Make a Paper Volcano
- Eruptions of Mount St. Helens: Past, Present, and Future by Robert I. Tilling, Lyn Topinka, and Donald A. Swanson
- Monitoring Active Volcanoes by Robert Tilling
- Volcanoes by Robert Tilling
- Volcanoes of the United States by Steven Brantley
- Volcano Hazard Fact Sheets
- Volcano resources and references
- Volcano Hazards Program
- Alaska Volcano Observatory
- Cascades Volcano Observatory
- Hawaiian Volcano Observatory

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Volcanoes of the United States

Online Version 1.1

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Volcano FAQs

Compiled by the
Geologic Inquiries Group

1. Could a volcanic eruption occur in my area?

Map showing volcanoes *(North and Central American Volcanoes)*
Frequency of eruptions in hazard areas

2. What causes volcanic activity?

The nature of volcanoes
Plate Tectonics, Hot Spots, Ring of Fire

3. I understand that an extinct volcano exists near my home in the eastern US. Should I be concerned?

No. Through plate tectonics, the eastern U.S. has been isolated from the global tectonic features, tectonic plate boundaries and hot spots in the mantle, that cause volcanic activity. So, new volcanic activity is not possible now or in the near future. If you wait around several hundred million years, maybe...

Remnants of past volcanism are found in most areas of the earth, even where volcanoes have not erupted in hundreds of millions of years. They are very common.

4. What hazards are associated with volcanic activity?

General
Debris Flows
Aviation

5. Does a relationship exist between volcanoes and earthquakes?

Earthquakes as a volcanic process
Global distribution

6a. Are volcanic eruptions weather related?

Volcanic lightning
Can rain cause volcanic eruptions?

6b. Do volcanic eruptions affect the climate?

7. What are the warning signs of an eruption and how do we monitor them?

8. Who monitors volcanoes in the US / World? How are people warned?
   - US Volcano Observatories
   - Worldwide monitoring

9. Can we predict volcanic eruptions?

10. Why can't we control volcanic eruptions by diverting lava?

11. What is the U.S. Geological Survey doing to mitigate volcanic hazards?

12. Volcano Statistics
    - How many active volcanoes exist?
    - Is volcanic activity increasing worldwide?

13. How can I prepare for a volcanic eruption?

14. How are volcanoes beneficial to people?

15. How can I become a volcanologist?

Related Information

DANTE'S PEAK FAQ'S (frequently asked questions)

Information on Volcanoes
Education and Outreach

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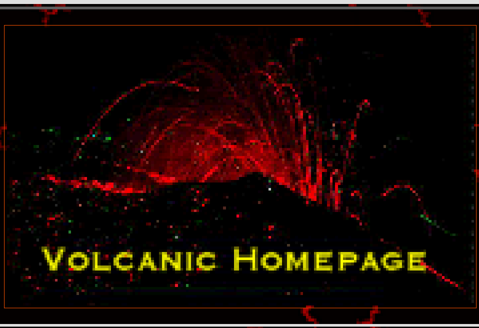
Maintained by Kathie Fraser and John Watson
Last modified 04-12-99 (krf)



The Volcanic Homepage

last updated April 10, 1997

Dr. Jonathan Dehn
Geological Survey of Japan, Hokkaido Branch
-or-
GEOMAR
Wischhof Str. 1-3, 24148 Kiel
Germany

Available at:

- Original Site
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Best with:

or

News- Photos- Animations- Reference- Volcanologists- JVH- Models- Links

This page is part of an ongoing project to model volcanic eruptions using a computer. *This also means that this page is constantly undergoing changes.* The research is funded by the Japanese Science and Technology Agency, the Geological Survey of Japan, and the National Science Foundation. The models here are available for everyone, but please be careful when using them. Keep in mind they represent only a ***possible*** scenario, and are not designed for use by the public for public volcanic hazard prediction or mitigation. For more information on safety, please read the Safety Report

---

Regular Features

Volcanic Homepage News
New additions and current omissions to this Web page.

Current Eruptions in Japan, courtesy of the VRC and ERI in Tokyo.

The Volcanic Photo Gallery
Photos of volcanoes and volcanic land forms from around the world. *UPDATED 12-December 1996*

Volcanic Animations
Animations, sounds, and movies of volcanoes.

The Volcanic Homepage presents: The Virtual Volcano

The Virtual Volcano COMING SOON
A volcanic tour through aspects of eruptions and volcanology *(Frames and Java required).*

Professional Features

Journal of the Volcanic Homepage

On-line publication of volcanic literature. Abstracts and poster presentations from various meetings. This feature will expand to include short *reviewed* articles.

Reference Materials on Volcanic Eruptions

Suggested reading and the Volcanic Homepage bibliographic database.

Guide to Volcanologists on the Internet

Safety Recommendations for Volcanologists and the Public

The report of the IAVCEI safety Sub-Committee, originally printed in the *Bulletin of Volcanology*, volume 56, pages 151-154.

Current Models

Simple Petrographic models

Programs for simple petrology as well as addresses and links to other sources

First Order Volcanic Models

Physical models of one aspect of an eruption as well as utility programs

Complete Eruption Type Models

One type of volcano, e.g. Cinder Cone, Lava Dome, etc...

Short List of Links to other Volcano Sites

or go to the *VOLCANIC JUMP STATION*

IAVCEI Home Page	Global Volcanism Program
Volcano World	Hawaiian Volcano Observatory
EOS Volcanology Team	Cascades Volcano Observatory
The Electronic Volcano	Alaskan Volcano Observatory

MTU Volcanoes Page	Nordic Volcanological Institute
Volcano Systems Center	UK Volcanologist's Homepage
Volcano Research Center, Tokyo	D. Johnson's Volcanic Activity
Volcaniclastic Processes	 *VOLCANIC JUMP STATION*

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[» Disaster Intensity Scales]

[» Water, Wind and Earth Game]

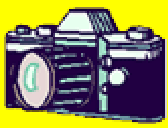
A volcano is a mountain that opens downward to a pool of molten rock below the surface of the earth. When pressure builds up, eruptions occur. Gases and rock shoot up through the opening and spill over or fill the air with lava fragments. Eruptions can cause lateral blasts, lava flows, hot ash flows, mudslides, avalanches, falling ash and floods. Volcano eruptions have been known to knock down entire forests. An erupting volcano can trigger tsunamis, flashfloods, earthquakes, mudflows and rockfalls.

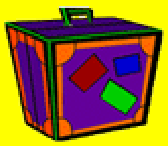
Active volcanoes in the U.S. are found mainly in Hawaii, Alaska, California, Oregon and Washington. The greatest chance of eruptions near areas where many people live is in Hawaii and Alaska. The danger area around a volcano covers about a 20-mile radius. In May 18, 1980, Mount St. Helens erupted in Washington state. It killed 58 people and caused more than $1 billion in property damage.

Fresh volcanic ash, made of pulverized rock, can be harsh, acidic, gritty, glassy and smelly. The ash can cause damage to the lungs of older people, babies and people with respiratory problems.


Things to Know


Pets and Disasters


Photos


Disaster Supply Kit


How to Protect Your Home from Disasters

FEMA for Kids

Federal Emergency Management Agency

NASA Facts

National Aeronautics and
Space Administration

Goddard Space Flight Center
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May 1998

NF-220

The Earth Science Enterprise Series

These articles consider Earth's many dynamic processes and their interactions.

Volcanoes and Global Climate Change

Volcanoes and Global Cooling

Volcanic gases are thought to be responsible for the global cooling that has sometimes been observed for a few years after a major eruption. The amount and global extent of the cooling depend on the force of the eruption, the amount of particular gases emitted, and, perhaps, on the location of the volcano with respect to the world's global atmospheric circulation patterns. When large masses of gases from the eruption reach the stratosphere, they can produce a large, widespread cooling effect. As a prime example, the effects of Mount Pinatubo, which erupted in June 1991, may have lasted a few years, serving to offset temporarily the predicted greenhouse warming effect.

Figure 1 illustrates that as volcanoes erupt, they blast huge clouds into the atmosphere. These clouds are made up of particles and gases, including sulfur dioxide. Millions of tons of sulfur dioxide gas can reach the stratosphere from a major eruption. There, the sulfur

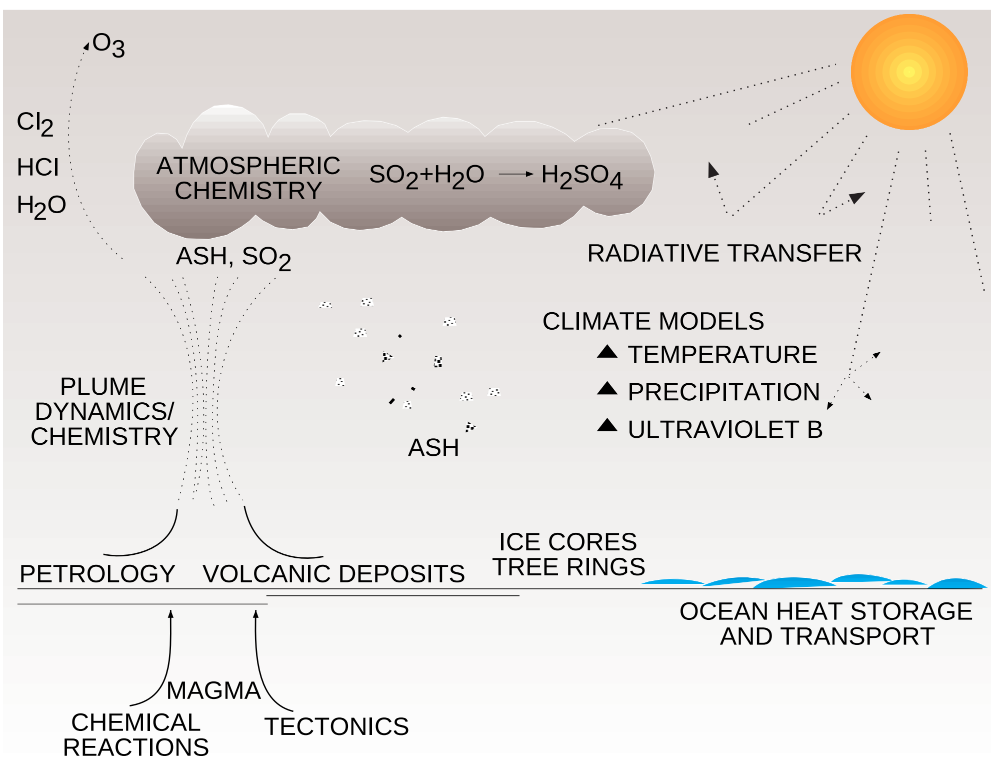


Figure 1. Volcanism studies are an important aspect of climate research (see chemistry glossary).

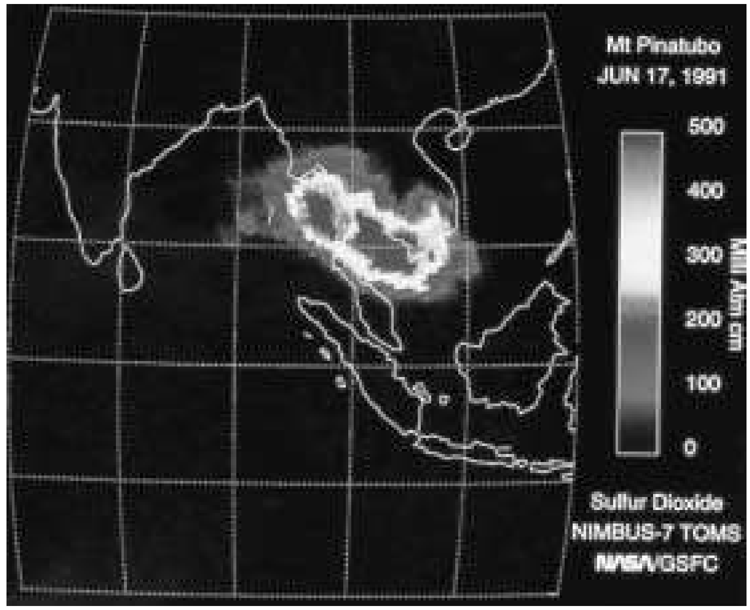
dioxide converts to tiny persistent sulfuric acid (sulfate) particles, referred to as aerosols. These sulfate particles reflect energy coming from sun, thereby decreasing the amount of sunlight reaching and heating the Earth's surface.

Short term global cooling often has been linked with some major volcanic eruptions. The year 1816 has been referred to as “the year without a summer.” It was a time of significant weather-related disruption in New England and in Western Europe with killing summer frosts in the United States and Canada. These strange phenomena were attributed to a major eruption of the Tambora volcano in 1815 in Indonesia. The volcano threw sulfur dioxide gas into the stratosphere, and the aerosol layer that formed led to brilliant sunsets seen around the world for several years.

But, not all volcanic eruptions, not even all *large* volcanic eruptions, produce global-scale cooling. Mount Agung in 1963 apparently caused a considerable decrease in temperatures around much of the world, whereas El Chichón in 1982 seemed to have little effect, perhaps because of its different location or because of the El Niño that occurred the same year. (See NASA Facts NF-211.) El Niño is a Pacific Ocean phenomenon, but it causes worldwide weather variations that may have acted to cancel out the effect of the El Chichón eruption.

Volcanoes and Ozone Depletion

Another possible effect of a volcanic eruption is the destruction of stratospheric ozone. Researchers now are suggesting that aerosol particles containing sulfuric acid from volcanic emissions may contribute to ozone loss. When chlorine compounds resulting from the breakup of chlorofluorocarbons (CFCs) in the stratosphere are present, the sulfate particles may serve to convert them into more-active



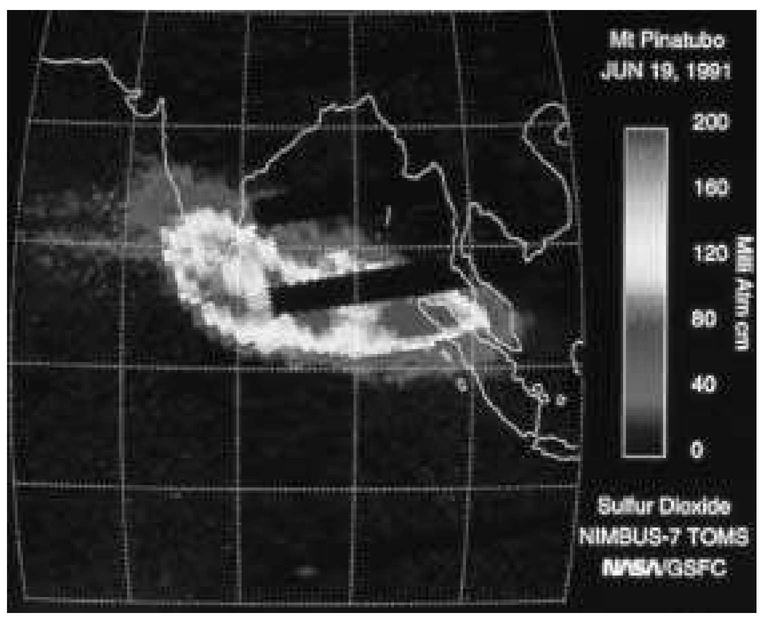


Figure 2. Images from NIMBUS-7: TOMS—June 17 (Top) and 19 (Bottom), 1991, showing the spread of sulfur dioxide from the Mt. Pinatubo eruption. The “gray scale” indicates the thickness the sulfur dioxide cloud layer would have had if it were obseved at standard surface conditions of temperature and pressure.

forms that may cause more-rapid ozone depletion. (See NASA Facts NF-198.)

Monitoring the Effects of Volcanoes

Space-based instruments are the only practical way to observe large and transitory volcanic eruption clouds. NASA's Total Ozone Mapping Spectrometer (TOMS) instruments have contributed significantly to our knowledge of the total amount of sulfur dioxide emitted into the atmosphere in the course of major volcanic eruptions. Figure 2 shows TOMS images of sulfur dioxide spreading across the Indian Ocean region following the eruption of Mount Pinatubo. Several weeks later the sulfur dioxide had spread around the world as observed by the Microwave Limb Sounder (MLS) instrument on NASA's Upper Atmosphere Research Satellite (UARS) (see Figure 3).

In addition to detecting the sulfur dioxide from Mount Pinatubo, TOMS has made similar observations of more than 100 volcanic events, including a major eruption from the Cerro Hudson volcano in Chile in 1991. TOMS instruments were launched on a Nimbus-7 spacecraft in 1978; a Russian Meteor-3 spacecraft in 1991; and on the Earth Probe and the Japanese Advanced Earth Observing System (ADEOS) platforms in 1996. A TOMS instrument is also scheduled to fly on a Russian-3M satellite in 2000.

Data from the Stratospheric Aerosol and Gas Experiment (SAGE II) instrument on NASA's Earth Radiation Budget Satellite (ERBS) have shown that during the first five months after the Mount Pinatubo eruption, the optical depth of the stratospheric aerosol increased up to 100 times in certain locations. Optical depth is a general measure of the capacity of a region of the atmosphere to prevent the passage of visible light through it. Greater optical depths mean greater blockage of the light. In this case, the increased optical depth means that considerably less of the sun's energy can get through the cloud to warm the Earth's surface. An advanced SAGE III instrument, which will make similar observations, is scheduled to be launched on a Russian Meteor-3M spacecraft in the second half of 1998.

A few years after an eruption most of the aerosol clouds will have decayed so that their effects on radiation will become negligible.

Observations of the effects of Mt. Pinatubo aerosols on global climate have been used to validate scientists' understanding of climate change and our ability to predict future climate. Researchers at NASA's Goddard

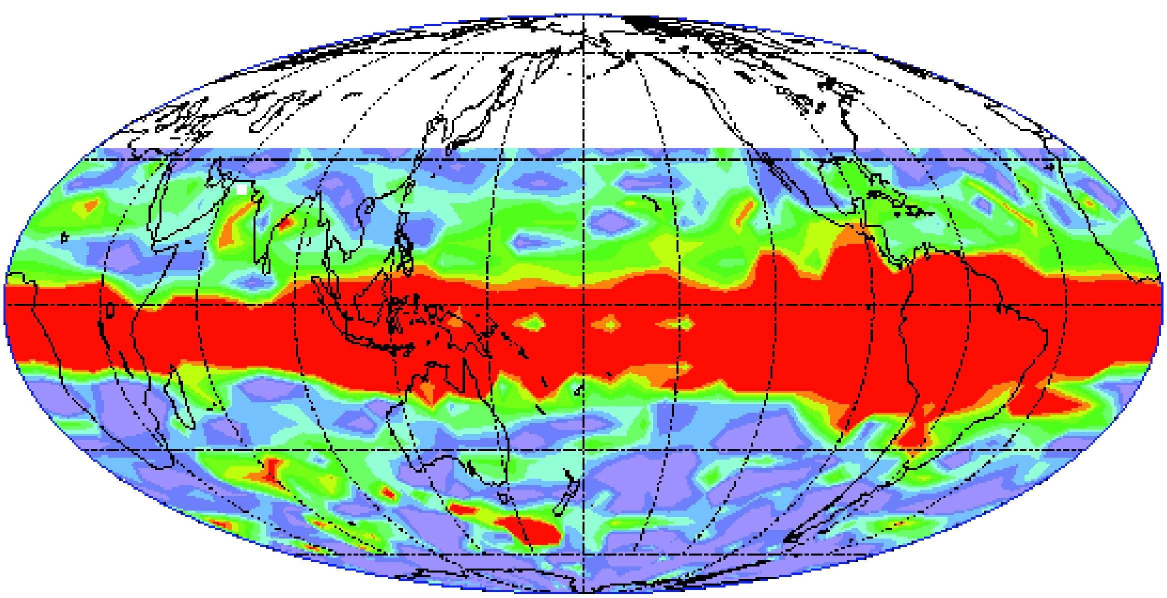


Figure 3. Images from the UARS satellite—sulfur dioxide cloud from Mt. Pinatubo on September 23, 1991, after dispersal around the world.

Institute for Space Studies in New York city have applied their general circulation model of Earth's climate to the problem. They have reported success in correctly predicting many of the effects of the sulfate aerosols from Mount Pinatubo's eruption on lowering global temperatures.

NASA Missions to Study Volcanoes

Some of NASA's past and present missions that contribute to the study of volcanoes are listed in the accompanying table. Included in the table is the Earth Observing System (EOS), the key element of NASA's Earth Science Enterprise. The first launch in the series of EOS satellites is scheduled to take place in 1998.

The High Resolution Infrared Radiometer (HRIR), first flown on NASA's Nimbus-1 satellite in 1964, has been used to observe both active and dormant volcanoes. On Nimbus-2, HRIR recorded energy changes from the volcanic activity on Surtsey, Iceland in 1966. The Multispectral Scanner (MSS) and Thematic Mapper (TM) instruments on the Landsat satellites have provided a long series of images of volcanic activity, such as venting, volcanic ash falls, and lava flows.

The EOS program will incorporate a series of satellites that will carry advanced instruments to provide a highly-accurate, self-consistent, and long-term data base of many aspects of Earth's atmosphere, land, and ocean characteristics. The information gained from this major effort to study Earth phenomena will expand our knowledge of the interactions of volcanoes with Earth's climate.

Glossary of Chemistry

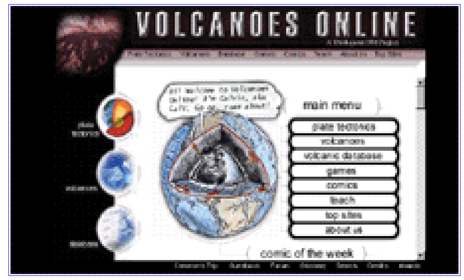
Cl_2	*chlorine molecule*
HCl	*hydrogen chloride*
H_2O	*water*
O_3	*ozone*
H_2SO_4	*sulfuric acid*
SO_2	*sulfur dioxide*

Earth Science Enterprise

Selected Missions Related to the Study of Volcanoes

Mission	Launch	Scientific Objective
Nimbus Series	1964-1978	Observe thermal emissions from active and dormant volcanoes (beginning with Nimbus-1 HRIR) Observe stratospheric sulfur dioxide (beginning with TOMS in 1978)
Landsat Series	1972-1998	High-spatial-resolution imagery of volcanic activity
TOMS/Meteor-3 TOMS/Earth Probe TOMS/ADEOS TOMS/Meteor-3M	1991 1996 1996 2000	Observe stratospheric sulfur dioxide and volcanic ash
SAGE III/ERBS SAGE III/Meteor-3M	1984 1998	Measure changes in stratospheric aerosol optical depth and the resulting changes in Earth's radiation budget due to volcanic emissions
Earth Observing System (EOS)	1998-	Observe Ozone Observe stratospheric sulfur dioxide Measure changes in stratospheric aerosol optical depth and changes in the radiation budget due to volcanic emissions Measure thermal anomalies due to volcanoes

Volcanoes Online



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1998 ThinkQuest Internet Challenge

Awards	First Place	
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Students	Cameron	West Valley High School, Yakima, WA, United States
	Jeroen	Katholieke Scholengemeenschap Etten-Leur, Etten-Leur, Netherlands
	Galvin	The Chinese High School, Singapore, Singapore
Coaches	Branden Taggart	West Valley High School, Yakima, WA, United States
	hans fevre le	scholengemeenschap etten-leur, etten-leur, Netherlands
	Hana Gwee	The Chinese High School, Singapore, Singapore

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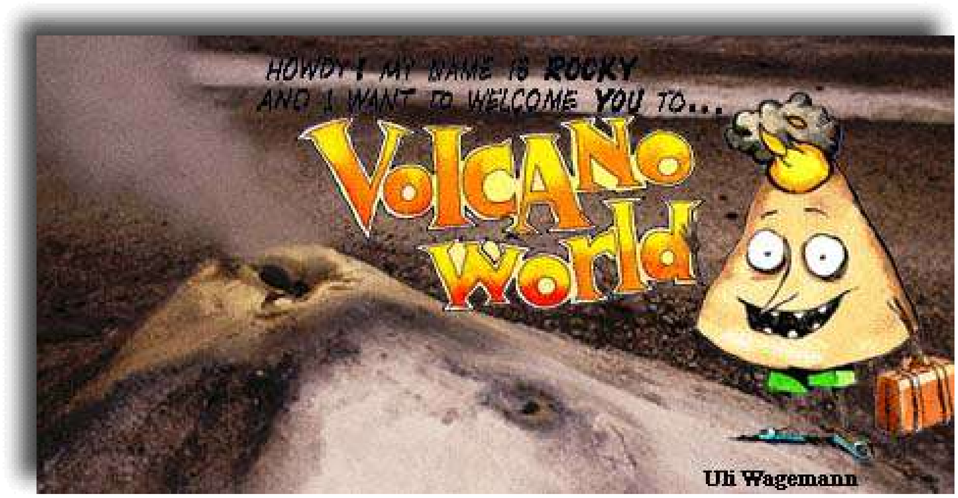

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Comments/Questions?

What is a rainbow?

Author Donald Ahrens in his text *Meteorology Today* describes a rainbow as "one of the most spectacular light shows observed on earth". Indeed the traditional rainbow is sunlight spread out into its spectrum of colors and diverted to the eye of the observer by water droplets. The "bow" part of the word describes the fact that the rainbow is a group of nearly circular arcs of color all having a common center.

Where is the sun when you see a rainbow?

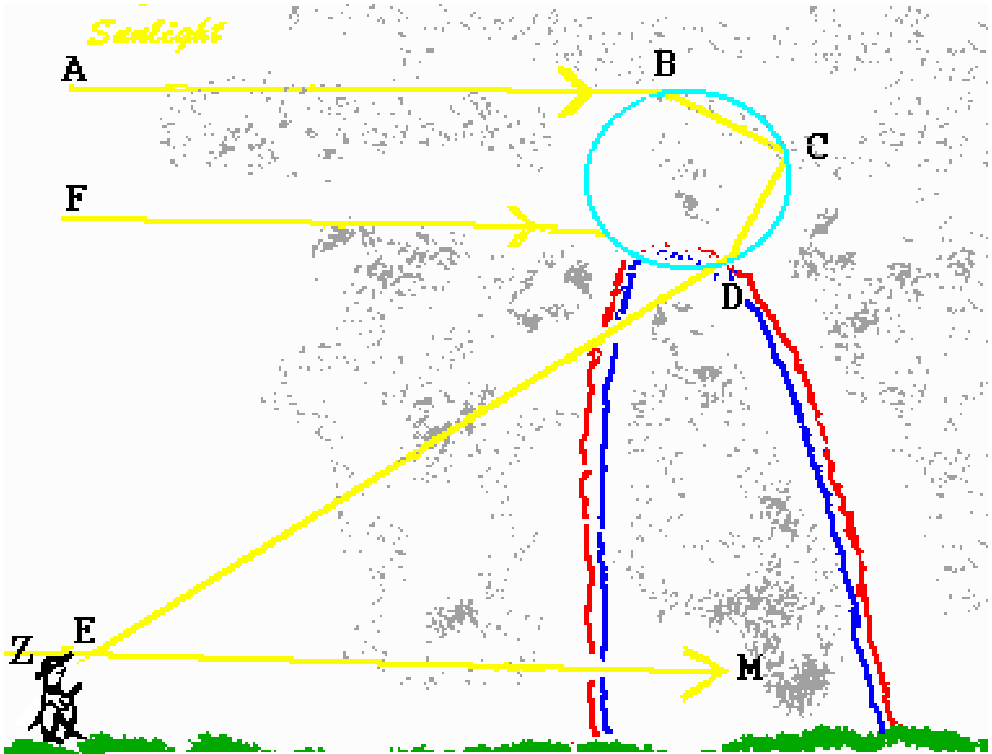
This is a good question to start thinking about the physical process that gives rise to a rainbow. Most people have never noticed that the sun is always behind you when you face a rainbow, and that the center of the circular arc of the rainbow is in the direction opposite to that of the sun. The rain, of course, is in the direction of the rainbow.

What makes the bow?

A question like this calls for a proper physical answer. We will discuss the formation of a rainbow by raindrops. It is a problem in optics that was first clearly discussed by Rene Descartes in 1637. An interesting historical account of this is to be found in Carl Boyer's book, *The Rainbow From Myth to Mathematics*. Descartes simplified the study of the rainbow by reducing it to a study of one water droplet and how it interacts with light falling upon it.

He writes:*"Considering that this bow appears not only in the sky, but also in the air near us, whenever there are drops of water illuminated by the sun, as we can see in certain fountains, I readily decided that it arose only from the way in which the rays of light act on these drops and* *pass from them to our eyes. Further, knowing that the drops are round, as has been formerly proved, and seeing that whether they are larger or smaller, the appearance of the bow is not changed in any way, I had the idea of making a very large one, so that I could examine it better.*

Descarte describes how he held up a large sphere in the sunlight and looked at the sunlight reflected in it. He wrote "*I found that if the sunlight came, for example, from the part of the sky*



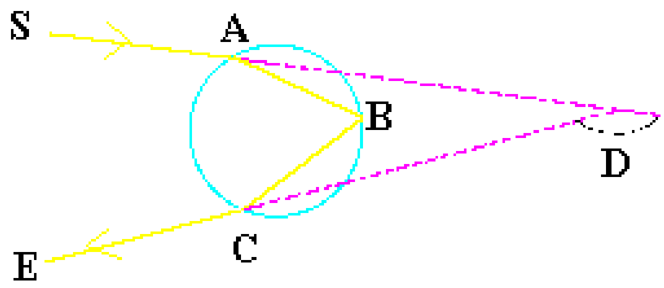
from Descartes"Discours de la Methode", 1637

which is marked AFZ

and my eye was at the point E, when I put the globe in position BCD, its part D appeared all red, and much more brilliant than the rest of it; and that whether I approached it or receded from it, or put it on my right or my left, or even turned it round about my head, provided that the line DE always made an angle of about forty-two degrees with the line EM, which we are to think of as drawn from the center of the sun to the eye, the part D appeared always similarly red; but that as soon as I made this angle DEM even a little larger, the red color disappeared; and if I made the angle a little smaller, the color did not disappear all at once, but divided itself first as if into two parts, less brilliant, and in which I could see yellow, blue, and other colors ... When I examined more particularly, in the globe BCD, what it was which made the part D appear red, I found that it was the rays of the sun which, coming from A to B, bend on entering the water at the point B, and to pass to C, where they are reflected to D, and bending there again as they pass out of the water, proceed to the point ".

This quotation illustrates how the shape of the rainbow is explained. To simplify the analysis, consider the path of a ray of monochromatic light through a single spherical raindrop. Imagine how light is refracted as it enters the raindrop, then how it is reflected by the internal, curved, mirror-like surface of the raindrop, and finally how it is refracted as it emerges from the drop. If we then apply the results for a single raindrop to a whole collection of raindrops in the sky, we can visualize the shape of the bow.

The traditional diagram to illustrate this is shown here as adapted from Humphreys, *Physics of the*



Air. It represents the path of one light ray incident on a water droplet from the direction SA. As the light beam enters the surface of the drop at A, it is bent (refracted) a little and strikes the inside wall of the drop at B, where it is reflected back to C. As it emerges from the drop it is refracted (bent) again into the direction CE. The angle D represents a measure of the deviation of the emergent ray from its original direction. Descartes calculated this deviation for a ray of red light to be about 180 - 42 or 138 degrees.

The ray drawn here is significant because it represents the ray that has the smallest angle of deviation of all the rays incident upon the raindrop. It is called the *Descarte* or *rainbow ray* and much of the sunlight as it is refracted and reflected through the raindrop is focused along this ray. Thus the reflected light is diffuse and weaker except near the direction of this rainbow ray. **It is this concentration of rays near the minimum deviation that gives rise to the arc of rainbow.**

The sun is so far away that we can, to a good approximation, assume that sunlight can be represented by a set of parallel rays all falling on the water globule and being refracted, reflected internally, and refracted again on emergence from the droplet in a manner like the figure. Descartes writes

I took my pen and made an accurate calculation of the paths of the rays which fall on the different points of a globe of water to determine at which angles, after two refractions and one or two reflections they will come to the eye, and I then found that after one reflection and two refractions there are ***many more rays*** *which can be seen at an angle of from forty-one to forty-two degrees than at any smaller angle; and that there are none which can be seen at a larger angle"* (the angle he is referring to is 180 - D).

A typical raindrop is spherical and therefore its effect on sunlight is symmetrical about an axis through the center of the drop and the source of light (in this case the sun). Because of this symmetry, the two-dimensional illustration of the figure serves us well and the complete picture can be visualized by rotating the two dimensional illustration about the axis of symmetry. The symmetry of the focusing effect of each drop is such that whenever we view a raindrop along the line of sight defined by the *rainbow ray*, we will see a bright spot of reflected/refracted sunlight. Referring to the figure, we see that the *rainbow ray* for red light makes an angle of 42 degrees between the direction of the incident sunlight and the line of sight. Therefore, as long as the raindrop is viewed along a line of sight that makes this angle with the direction of incident light, we will see a brightening. The rainbow is thus a circle of angular radius 42 degrees, centered on the antisolar point, as shown schematically here.

We don't see a full circle because the earth gets in the way. The lower the sun is to the horizon, the more of the circle we see -right at sunset, we would see a full semicircle of the rainbow with the top of the arch 42 degrees above the horizon. The higher the sun is in the sky, the smaller is the arch of the rainbow above the horizon.

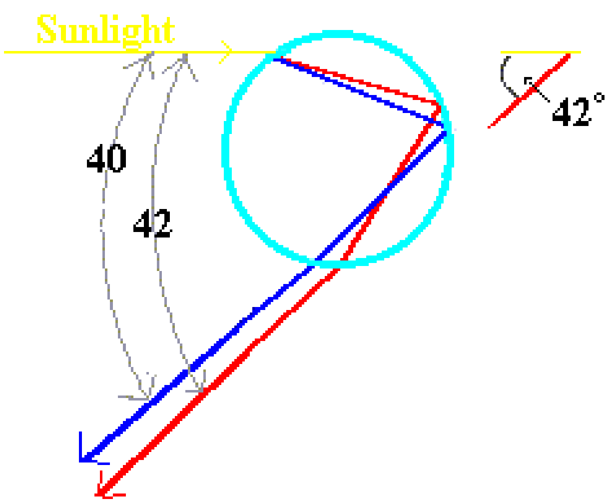
What makes the colors in the rainbow?

The traditional description of the rainbow is that it is made up of seven colors - red, orange, yellow, green, blue, indigo, and violet. Actually, the rainbow is a whole continuum of colors from red to violet and even beyond the colors that the eye can see.

The colors of the rainbow arise from two basic facts:

- Sunlight is made up of the whole range of colors that the eye can detect. The range of sunlight colors, *when combined*, looks white to the eye. This property of sunlight was first demonstrated by Sir Isaac Newton in 1666.
- Light of different colors is refracted by different amounts when it passes from one medium (air, for example) into another (water or glass, for example).

Descartes and Willebrord Snell had determined how a ray of light is bent, or refracted, as it traverses regions of different densities, such as air and water. When the light paths through a raindrop are traced for red and blue light, one finds that the angle of deviation is different for the two colors because blue light is bent or refracted more than is the red light.



This implies that when we see a rainbow and its band of colors we are looking at light refracted and reflected from *different raindrops*, some viewed at an angle of 42 degrees; some, at an angle of 40 degrees, and some in between. This is illustrated in this drawing, adapted from Johnson's *Physical Meteorology*. This rainbow of two colors would have a width of almost 2 degrees (about four times larger than the angular size as the full moon). Note that even though blue light is refracted more than red light in a single drop, we see the blue light on the inner part of the arc because we are looking along a different line of sight that has a smaller angle (40 degrees) for the blue.

Ana excellent laboratory exercise on the mathematics of rainbows is here, and F. K. Hwang has produced a fine Java Aplet illustrating this refraction, and Nigel Greenwood has written a program that operates in MS Excel that illustrates the way the angles change as a function of the sun's angle.

Ben Lanterman has made available several beautiful photographs of rainbows on the web.

What makes a double rainbow?

Sometimes we see two rainbows at once, what causes this? We have followed the path of a ray of sunlight as it enters and is reflected inside the raindrop. But not all of the energy of the ray escapes the raindrop after it is reflected once. A part of the ray is reflected again and travels along inside the drop to emerge from the drop. The rainbow we normally see is called the **primary** rainbow and is produced by one internal reflection; the **secondary** rainbow arises from two internal reflections and the rays exit the drop at an angle of 50 degrees° rather than the 42°degrees for the red primary bow. Blue light emerges at an even larger angle of 53 degrees°. his effect produces a secondary rainbow that has its colors reversed compared to the primary, as illustrated in the drawing, adapted from the Science Universe Series *Sight, Light, and Color*.

It is possible for light to be reflected more than twice within a raindrop, and one can calculate where the higher order rainbows might be seen; but these are never seen in normal circumstances.

Why is the sky brighter inside a rainbow?

Notice the contrast between the sky inside the arc and outside it. When one studies the refraction of sunlight on a raindrop one finds that there are many rays emerging at angles smaller than the *rainbow ray*, but essentially no light from single internal reflections at angles greater than this ray. Thus there is a lot of light within the bow, and very little beyond it. Because this light is a mix of all the rainbow colors, it is white. In the case of the secondary rainbow, the *rainbow ray* is the smallest angle and there are many rays emerging at angles greater than this one. Therefore the two bows combine to define a dark region between them - called Alexander's Dark Band, in honor of Alexander of Aphrodisias who discussed it some 1800 years ago!

What are Supernumerary Arcs?

In some rainbows, faint arcs just inside and near the top of the primary bow can be seen. These are called supernumerary arcs and were explained by Thomas Young in 1804 as arising from the interference of light along certain rays within the drop. Young's work had a profound influence on theories of the physical nature of light and his studies of the rainbow were a fundamental element of this. Young interpreted light in terms of it being a wave of some sort and that when two rays are scattered in the same direction within a raindrop, they may interfere with each other. Depending on how the rays mesh together, the interference can be constructive, in which case the rays produce a brightening, or destructive, in which case there is a reduction in brightness. This phenomenon is clearly described in Nussenzveig's article "The Theory of the Rainbow" in which he writes: *"At angles very close to the rainbow angle the two paths through the droplet differ only slightly, and so the two rays interfere constructively. As the angle increases, the two rays follow paths of substantially different lengths. When the difference equals half of the wavelength, the interference is completely destructive; at still greater angles the beams reinforce again. The result is a periodic variation in the intensity of the scattered light, a series of alternately bright and dark bands."*

Mikolaj and Pawel Sawicki have posted several beautiful photographs of rainbows showing these arcs.

The "purity" of the colors of the rainbow depends on the size of the raindrops. Large drops (diameters of a few millimeters) give bright rainbows with well defined colors; small droplets (diameters of about 0.01 mm) produce rainbows of overlapping colors that appear nearly white. And remember that the models that predict a rainbow arc all assume spherical shapes for raindrops.

There is never a single size for water drops in rain but a mixture of many sizes and shapes. This results in a composite rainbow. Raindrops generally don't "grow" to radii larger than about 0.5 cm without breaking up because of collisions with other raindrops, although occasionally drops a few millimeters larger in radius have been observed when there are very few drops (and so few collisions between the drops) in a rainstorm. Bill Livingston suggests: " If you are brave enough, look up during a thunder shower at the falling drops. Some may hit your eye (or glasses), but this is not fatal. You will actually see that the drops are distorted and are oscillating."

It is the surface tension of water that moulds raindrops into spherical shapes, if no other forces are acting on them. But as a drop falls in the air, the 'drag' causes a distortion in its shape, making it somewhat flattened. Deviations from a spherical shape have been measured by suspending drops in the air stream of a vertical wind tunnel (Pruppacher and Beard, 1970, and Pruppacher and Pitter, 1971). Small drops of radius less than 140 microns (0.014 cm) remain spherical, but as the size of the drop increases, the flattening becomes noticeable. For drops with a radius near 0.14 cm, the height/width ratio is 0.85. This flattening increases for larger drops.

Spherical drops produce symmetrical rainbows, but rainbows seen when the sun is near the horizon are often observed to be brighter at their sides, the vertical part, than at their top. Alistair Fraser has explained this phenomenon as resulting from the complex mixture of size and shape of the raindrops. The reflection and refraction of light from a flattened water droplet is not symmetrical. For a flattened drop, some of the rainbow ray is lost at top and bottom of the drop. Therefore, we see the rays from these flattened drops only as we view them horizontally; thus the rainbow produced by the large drops is is bright at its base. Near the top of the arc only small spherical drops produce the fainter rainbow.

What does a rainbow look like through dark glasses?

This is a "trick" question because the answer depends on whether or not your glasses are Polaroid. When light is reflected at certain angles it becomes polarized (discussed again quite well in Nussenzveig's article), and it has been found that the *rainbow angle* is close to that angle of reflection at which incident, unpolarized light (sunlight) is almost completely polarized. So if you look at a rainbow with Polaroid sunglasses and rotate the lenses around the line of sight, part of the rainbow will disappear!

Other Questions about the Rainbow

Humphreys (Physics of the Air, p. 478) discusses several "popular" questions about the rainbow:

- "What is the rainbow's distance?" It is nearby or far away, according to where the raindrops are, extending from the closest to the farthest illuminated drops along the elements of the rainbow cone.

- Why is the rainbow so frequently seen during summer and so seldom during winter?" To see a rainbow, one has to have rain and sunshine. In the winter, water droplets freeze into ice particles that do not produce a rainbow but scatter light in other very interesting patterns.
- "Why are rainbows so rarely seen at noon?" Remember that the center of the rainbow's circle is opposite the sun so that it is as far below the level of the observer as the sun is above it.
- "Do two people ever see the same rainbow?" Humphreys points out that "since the rainbow is a special distribution of colors (produced in a particular way) with reference to a definite point - the eye of the observer - and as no single distribution can be the same for two separate points, it follows that two observers do not, and cannot, see the same rainbow." In fact, each eye sees its own rainbow!!
  Of course, a camera lens will record an image of a rainbow which can then be seen my many people! (thanks to Tom and Rachel Ludovise for pointing this out!)
- "Can the same rainbow be seen by reflection as seen directly?" On the basis of the arguments given in the preceding question, bows appropriate for two different points are produced by different drops; hence, a bow seen by reflection is not the same as the one seen directly".

What are Reflection Rainbows?

A reflection rainbow is defined as one produced by the reflection of the source of incident light (usually the sun). Photographs of them are perhaps the most impressive of rainbow photographs. The reflected rainbow may be considered as a combination of two rainbows produced by sunlight coming from two different directions - one directly from the sun, the other from the reflected image of the sun. The angles are quite different and therefore the elevation of the rainbow arcs will be correspondingly different. This is illustrated in a diagram adapted from Greenler"s *Rainbows, Halos, and Glories*. The rainbow produced by sunlight reflected from the water is higher in the sky than is the one produced by direct sunlight.

What is a Lunar Rainbow?

A full moon is bright enough to have its light refracted by raindrops just as is the case for the sun. Moonlight is much fainter, of course, so the lunar rainbow is not nearly as bright as one produced by sunlight. Lunar rainbows have infrequently been observed since the time of Aristotle or before. A graphic description of one was writen by Dr. Mikkelson.

Rainbows and Proverbs

There is a delightful book by Humphreys entitled *Weather Proverbs and Paradoxes*. In it, he discusses the meteorological justifications of some proverbs associated with rainbows, such as "Rainbow at night, shepherd's delight;Rainbow in morning, shepherds take warning,"If there be a rainbow in the eve,It will rain and leave; But if there be a rainbow in the morrow It will neither lend nor borrow", and Rainbow to windward, foul fall the day; Rainbow to leeward, damp runs away."

The meteorological discussion Humphreys presents is appropriate for the northern temperate zones that have a prevailing wind, and also for a normal diurnal change in the weather.

Experiments

William Livingston, a solar astronomer who has also specialized in atmospheric optical phenomena suggests the following: "Try a hose spray yourself. As you produce a fine spray supernumeraries up to order three become nicely visible. "Try to estimate the size of these drops compared to a raindrop. ..."Another thing to try. View a water droplet on a leaf close-up - an inch from your eye. At the *rainbow angle* you may catch a nice bit of color!"

In Minnaert's excellent book *Light and Colour in the Open Air* you can find a number of experiments on how to study the nature of rainbows. Here is an illustration of one of his suggestions. Other demonstration projects are listed here .

Meg Beal, while a seventh-grader, prepared a science fair project that illustrated the nature of rainbows. The Beal family provided a photograph (1MB) of her excellent demonstration.

For those wanting to try to demonstrate the nature of a rainbow in a classroom, here are examples.

An informative tutorial on optics can be found here.

I am indebted to William C. Livingston, astronomer at the National Optical Astronomy Observatory in Tucson Arizona for his expert assistance in preparing this paper, and to Seth Sharpless for his critical reading of the manuscript. Charles A. Knight, an expert on rain at the National Center for Atmospheric Physics, provided valuable guidance on the interesting properties of raindrops.

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Beverly T. Lynds

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- Internet Guides

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Ask an Expert: Physical Education (See Fitness/Health/Medicine)

Ask an Expert: Reference

- Reference Librarian (Cedar Falls Library)
- Reference Librarian (Internet Public Library)
- Reference Librarian (Kids Connect)
- Reference Librarian (Georgia Southern University)

Ask an Expert: Science

- Agriculture (Oregon Dept. of Agriculture)
- Astronaut (Different Astronaut each month)
- Astronomy (Drs Guhathakurta and Strachan)
- Astronomy (Dr. Odenwald)
- Astronomy (George Mason University)
- Astronomy (Case Western Reserve University)
- Diamonds (Van-Daaz)
- Dinosaurs (Dino Russ)
- Earth Scientist (University of Hawaii)
- Energy (Energy Efficiency and Renewable Energy Clearinghouse)
- Engineer (Society of Women Engineers)
- Entomology (Ask Dr. Bug)
- Genetics (Non-Human Vertebrates)
- Geology (Geological Survey of Canada)
- Geology (Geological Survey of Canada: Atlantic)

- Geology (US Geological Survey)
- Gravity (U of Maryland)
- Ocean or Marine Animals (Ask Shamu)
- Ocean or Ocean Animals (Jake the Sea Dog)
- Ocean or Oceanography (US Navy)
- Oceanography (Ocean World)
- Physical Science (ALCOM)
- Physics (Dr. Physics)
- Physics (How Stuff Works)
- Plants/Gardening(Ask the Plant Man)
- Science (General: Franklin Institute)
- Science (General: Patricia Higby)
- Science (General: STANet)
- Science (Many Disciplines: Mad Scientist Network)
- Science (Many Disciplines: National Public Radio)
- Science (Many Disciplines: Schools Online)
- Science (Many Disciplines: Scientific American)
- Volcanoes (Ask a Volcanologist)
- Weather/Environment (Scientific American)
- Zoo Animals (Micke Grove Zoo)

Ask an Expert: Social Studies

- Canadian Geography (Ask the Harkster)
- Canadian Law (ACJNet)
- Environment (Scientific American)
- Newfoundland (Centre for Newfoundland Studies)

Ask an Expert: Technology

- Construction (Professor Construction)
- Renovation (Renovator)
- Woodworking (Windsor Plywood)

Top of Page

Previous Screen

Be very, very careful what you put into that head,
because you will never, ever get it out.
Thomas Cardinal Wolsey (1471-1530)

Bad Meteorology

Click on the symbol for its explanation.

This material is dedicated to teachers who wish to get it right.

By bad meteorology, I do not mean bad weather.

This page is about intellectual disasters, not weather disasters.

*T*his page is prepared by Alistair B. Fraser who retains copyright to the material (unless otherwise acknowledged). However, as the object of the material is educational --- to replace bad science with good science --- the material can be freely used for non-commercial purposes, with the proviso that any use of Fraser's images must be credited with © Alistair B. Fraser, and any quotations must bear attribution.

*S*uggestions of ideas which might be beneficial to include on this page can be sent to me at alistair@fraser.cc . Also, please send me critical comments on any stupidities that I inadvertently introduce.

*T*he *Bad Science* and *Bad Meteorology* pages have been cited by over 3000 other web pages, and in books, magazines, and on TV.

Examples of Bad Meteorology:

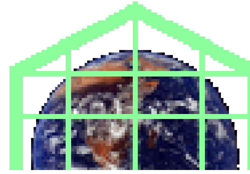
The reason clouds form when air cools is that cold air cannot hold as much water vapor as warm air.

*W*ash your hands of this emetic explanation .

Raindrops are shaped like teardrops.

*W*eep over this artistic licentiousness .

The greenhouse effect is caused when gasses in the atmosphere behave as a blanket and trap radiation which is then reradiated to the earth.



*R*eject this explanation as nothing but hot air .

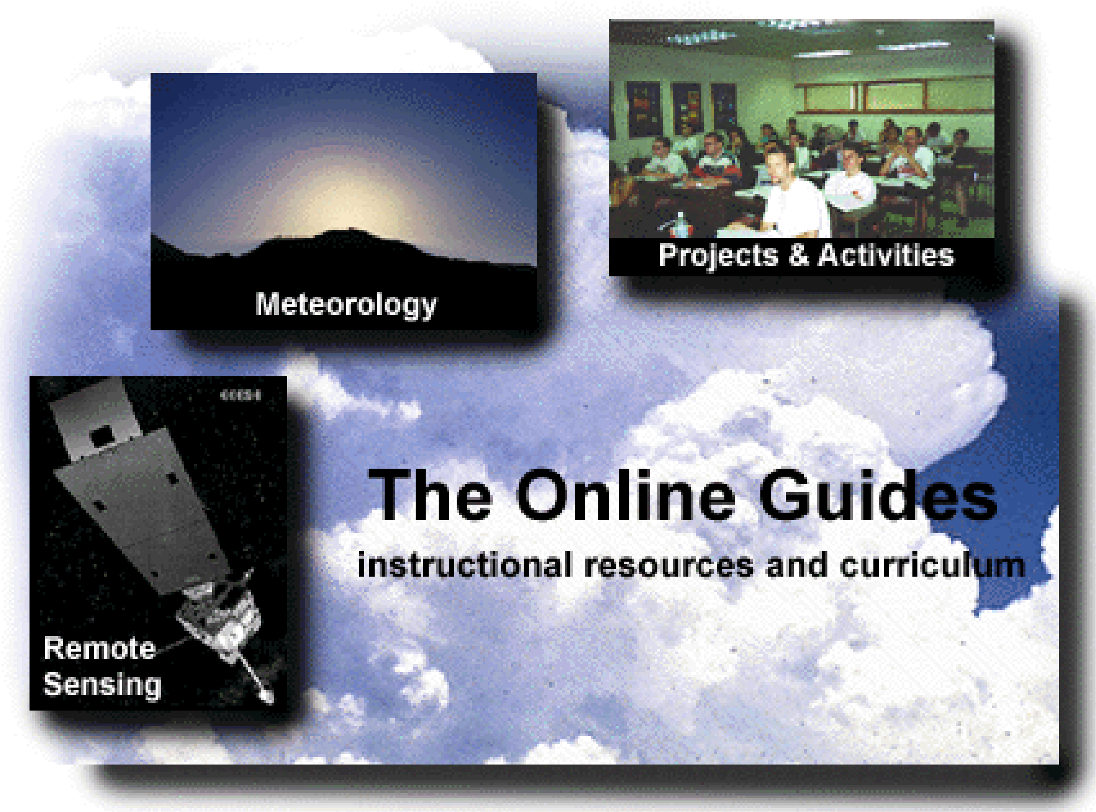
The water in a sink (or toilet) rotates one way as it drains in the northern hemisphere and the other way in the southern hemisphere. Called the Coriolis Effect, it is caused by the rotation of the earth.

*T*his nonsense deserves to be flushed .

The Bad Meteorology FAQ

Proffering Garbage as Gems

- *T*he results of a *Badness Survey* .



Graphic by: Steven E. Hall

Welcome to the WW2010 Online Guides, the next evolution phase of our web-based instructional resources. Formerly known as the Guide to Meteorology, we are expanding these resources beyond the scope of meteorology to other disciplines like climate, remote sensing and global change. We will attempt to present these topics not as individual sciences, but as integral components of a much larger system, learning about the planet on which we live. Available Online Guides include:

Guides

Last Update: 09/02/99

Meteorology
Instructional modules that introduce topics in meteorology from fronts to El Niño.

Remote Sensing
Instructional modules that introduce remote sensing technologies and their applications in meteorology.

Reading and Interpreting Weather Maps
Instructional resources that provide valuable information for the correct interpretation of weather products accessible (or soon to be accessible) from WW2010.

Projects & Activities
Curriculum aids that provide teachers with a blueprint for integrating web-based educational resources into the classroom.

The Online Guides use multimedia technology and the dynamic capabilities of the web. These resources incorporate text, colorful diagrams, animations, computer simulations, audio and video to introduce topics and concepts for a wide variety of disciplines. Selected pages link to (or will soon link to) current weather products, allowing the user to apply what the user has learned to real-time weather data. The Online Guides are an important component of the WW2010 Hybrid Multimedia Environment. Not only are they a part of this web server, but they are also (or will soon be) available for local access via educational CD-ROM.

The target audience for the Online Guides is high school and undergraduate level students. However, these resources have been used by instructors throughout K-12, undergraduate and graduate level education. Contents of the Online Guides were developed by graduate students and faculty through our efforts in the Collaborative Visualization Project (CoVis), which was funded by the National Science Foundation. These resources have been reviewed by faculty and scientists at the University of Illinois and the Illinois State Water Survey. Many of these resources were tested in a classroom environment and have been modified based upon teacher and student feedback.

The navigation menu (left) for this resource is called "Online Guides" and the available guides are listed as menu items, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

UM Weather

Connecting You To The World Of Weather

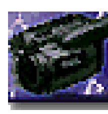
Welcome to **UM Weather**, the Internet's premier source of weather information since 1994. Providing access to thousands of forecasts, images, and the Net's largest collection of weather links, UM Weather is the most comprehensive and up-to-date source of weather data on the Web. UM Weather is brought to you by the Department of Atmospheric, Oceanic and Space Sciences at the University of Michigan.

FastForecast...Enter a city, state, country, zip code, or station code for the current National Weather Service forecast:

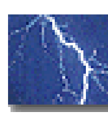
[ ] Get It Reset

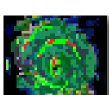
Examples: "NY", "Albany", "11234", "ALB", or "France"

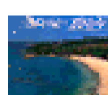

WeatherSites
The list that made us famous. Nearly three hundred WWW, gopher, telnet, and FTP weather sites -- the most comprehensive weather index on the Internet.


WeatherCams
Live and daily pictures of weather conditions at over 700 locations around North America.

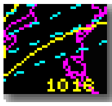

USA Weather
City-by-city forecasts, conditions, warnings, and weather graphics for each of the fifty states.


Canada Weather
Regional forecasts, advisories, conditions, and reports for each of the Canadian Provinces and Territories.

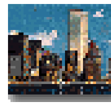

Radar and Satellite
Point-and-click access to the Internet's best Nexrad and color satellite imagery.


Tropical Weather
The Net's most comprhensive collection of tropical storm-related links, including National Hurricane Center reports and incredible graphics.

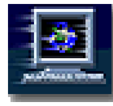
[Ski Weather](#)
Snow conditions and mountain-specific weather reports directly from the National Weather Service.



[WeatherMaps](#)
The Net's best surface and upper air analyses, including temperature maps, regional weather plots, and jet stream maps.



[Travel Cities Weather](#)
Nexrad radar, color satellite photos, climate information, forecasts, and conditions for thirty popular destinations nationwide.



[Weather Software](#)
The Internet's only weather software archive, providing access to over two dozen of the best weather applications for Macs and PCs.

UM Weather pages have been visited over **689209100** times. Last modified: June 30, 2004.

METEOROLOGICAL SERVICE OF CANADA
THE SOURCE® for Weather in Canada
CANADA'S MOST POPULAR WEATHER SITE

WE HAVE MOVED TO

www.weatheroffice.ec.gc.ca

You will be redirected automatically in 15 seconds.

Please update your bookmarks now as weatheroffice.com will be de-commissioned on.

October 31, 2001

Click here to go to this page on the new site

Click here for

WEATHERSTORE / BUSINESS SERVICES

IMPORTANT...Bookmark this new NEW WEATHERSTORE URL

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Canada

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Meteorological Service of Canada (MSC)

Weather Warnings

5-day weather
Text Forecasts
Marine weather
Aviation weather
Seasonal forecasts

RADAR Imagery
Satellite Imagery
Lightning
Weather Maps

Hurricane Information
Sea Ice Information
Air Quality Forecasts
Climate Data

Business Services
Skywatchers
MSC Careers
Frequently Asked Questions
Links/Partners

Choose a Province, Territory, City or Marine Symbol

[Graphics off] | [Format for print] |

Important Notices and Disclaimers

Created : 2002-12-31
Modified : 2002-12-31
Reviewed : 2002-12-31
Url of this page : http://www.weatheroffice.ec.gc.ca/canada_e.html

Canada

The Green Lane™,
Environment Canada's World Wide Web Site.

WorldClimate

What the weather is *normally* like for tens of thousands of places worldwide!

City or town name: [ ] Search

Enter the name of the **CITY** above. Don't enter a country or state name. If you are not sure of the spelling, enter just the first few letters of the name. **For foreign cities, try entering the name in the local language, for example *Venezia* for Venice.**

Popular cities: London - Berlin - Rome - New York - Toronto - Sydney - Moskva (Moscow) - Tokyo - Beijing - Baghdad - San Francisco Bay Area - Cairo - Bangkok - Lima - Orlando - Calcutta (Kolkata) - Cape Town - Lagos

WorldClimate.com contains over 85,000 records of world climate data (historical weather averages) from a wide range of sources. See about worldclimate for details and instructions. **At present, all placenames and COUNTRIES are shown with the names they had *at the time the data was recorded.* I am well aware many, especially in eastern Europe, have changed country since!** Please also read the frequently asked questions.

NEWS

(updated 2004-Mar-12):

This site has been essentially unchanged since it was first written in 1996.

A totally rewritten new version, with **much** more data and improved searching options (by current country/state etc) is under development. It also has corrected placenames and countries. This will be online soon.

WorldClimate

 Web Design and Programming by Robert Hoare. Frequently Asked Questions. Created 1 Aug 1996. Latest Update (minor changes) 12 sep 2003. v261

Magnetism Theme Page

Below are the CLN "Theme Pages" which support the study of electricity and magnetism. CLN's theme pages are collections of useful Internet educational resources within a narrow curricular topic and contain links to two types of information. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are links to instructional materials (lesson plans) which will help teachers provide instruction in this theme.

- Electricity (Concepts) Theme Page
- Electronics (Circuitry) Theme Page
- Lightning Theme Page

General Magnetism Resources

Here are a number of links to other Internet resources which contain information and/or other links related to Magnetism. Please read our disclaimer.

- **AskERIC Lesson Plans: Physical Sciences**

  The above link is to AskEric's Physical Science page if you wish to browse/search their site yourself. Or, use the links below to go directly to two lesson plans specifically about magnetism.

  - Magnetic Fields and Bermuda Triangles High school students can use this activity to learn how to map a magnetic field and to find how magnetic fields can combine to form a complex resultant field.
  - Magnets An introduction to magnets for primary students.

- **Electricity and Magnetism**

  More than a dozen experiments on electricity and magnetism designed for intermediate students. There are about five experiments on magnetism.

- **Electricity and Magnetism**

  The basic concepts of electricity and magnetism are illustrated through the use of animation. (Shockwave required) Students are introduced to static charge, moving charge, voltage, resistance, and current. Magnetism and how it relates to electricity is also presented.

- **Gallery of Electromagnetic Personalities**

  Biographical vignettes of scientists who made significant contributions to the study of electromagnetism.

- **How An Electromagnet Works**

  An explanation about the concepts underlying electromagnetism created for kids and complete with diagrams. A few experiments are also suggested.

- [MagLev: A Physics Viewpoint]

MagLev (magnetic levitation) technology is the concept underlying research into the use of magnets to propel trains. This site presents the basic principles of the concepts which should be understandable by high school students.

- MagLev Technology

The Argonne Community of Teachers Network offers a downloadable Teacher's Handbook with student activities on magnetism and electromagnetism. The site also has links to other MagLev web sites.

- Magnetism

Here's a lesson on magnetism complete with a mini quiz, homework exercises, and a test.

- Magnetism, Electricity and Health Reform

An overview of the use of electricity and magnetism in the treatment of disease.

- Magnet Man

All sorts of experiments with magnets from the very basic to magnets interacting with other magnets, magnets and conductors, and magnetic levitation.

- National Museum of Science and Technology

This Canadian museum is not easily browsed; however, a search of the site using the keyword "magnet" turned up a number of hits that may be useful to the classroom teacher. Use the button above to search the site yourself for this or similar terms. Below are direct links to three of the best resources.

  - Background Information for Magnets
  - Lesson Plan Ideas - Magnets
  - Student Activities

- Physical Science Activity Manual

This Manual contains hands-on Chemistry & Physics activities that can be downloaded in either MAC (MS WORD) or Windows (Wordperfect) versions. The manual is neither a lab manual nor a series of lesson plans. Rather, it provides the teacher with background information and a collection of student-centered activities which s/he can adapt to local conditions. There are two documents dealing with magnetism and electromagnetism.

- Project PHYSLab

Project PHYSLab has a collection of high school physics labs (including some on Magnetism) developed by participants in an annual, three week workshop. This link is to the home page of the project. From there, enter "Labs Available Online" to find the labs. Since each of these is done by a different teacher, the quality of the lab and the detail associated with it will vary.

- Science Toys You Can Make With Your Kids

The author of this online book describes a variety of science toys that can be constructed and then goes on to explain the concepts behind the toys. Two chapters in the book are dedicated to magnetism and electromagnetism. Teachers could use these ideas for demonstrations and/or student activities.

- Smile Program Physics Index

  Teachers participating in the SMILE (Science and Mathematics Initiative for Learning Enhancement) summer session programs each create a single concept lesson plan. This database has over 30 lesson plans in their section on Electricity and Magnetism. Caution: Since there is a wide number of authors who have contributed to the database, the detail and quality of the lesson plans will vary.

- Snacks about Magnetism

  "Snacks" from the Exploratorium are miniature science exhibit that teachers can make using common, inexpensive, easily available materials. This page leads to about a dozen activities/experiments to demonstrate magnetism concepts.

Top of Page

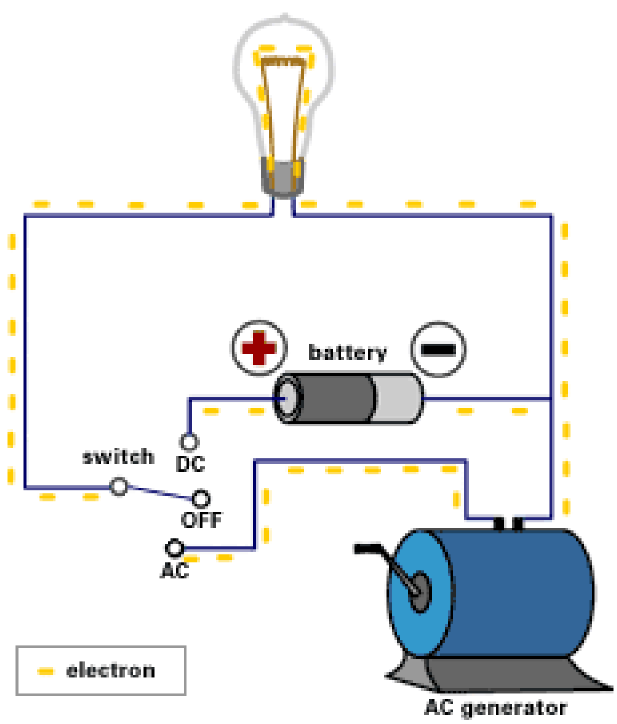
Note: The sites listed above will serve as a source of curricular content in Magnetism. For other resources in Science (e.g., curricular content in Earth Science, General Science, Life Science, or Physical Science), or for lesson plans and theme pages, click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

AC/DC: What's the Difference?

In 1887 direct current (DC) was king. At that time there were 121 Edison power stations scattered across the United States delivering DC electricity to its customers. But DC had a great limitation -- namely, that power plants could only send DC electricity about a mile before the electricity began to lose power. So when George Westinghouse introduced his system based on high-voltage alternating current (AC), which could carry electricity hundreds of miles with little loss of power, people naturally took notice. A "battle of the currents" ensued. In the end, Westinghouse's AC prevailed.

But this special feature isn't about the two electrical systems and how they worked. Rather, it's a simple explanation that shows the difference between AC and DC.



To find out more about alternating and direct current, what exactly an electric current is, and two ways that the currents can be produced, check out the interaction to the left and the pages that follow.

- DC (Direct Current)
- OFF
- AC (Alternating Current)

Click on an object in the illustration to find out more, or select a link below.

Go inside the: wire | battery | AC generator | light bulb

AC/DC | Music

The Film & More | Special Features | Timeline | Gallery | Teacher's Guide

The American Experience | Kids | Feedback | Search | Shop | Subscribe

ARTICLES ABOUT "ELECTRICITY"

New Explanations, Alternate Mental Toolkit

William J. Beaty
Electrical Engineer, U. of Washington

Jump down to Build-it Projects.

What Is "Electricity?"
There is a simple answer to this question. Really. Not the one you expect, though.

Electricity FAQ (Frequently-asked Questions)
Browse these Frequently Asked Questions, or submit a new one.

Barriers to Understanding Electricity
Twenty misconceptions which prevented me from understanding simple electrical science as a student. Maybe they cause trouble for you as well?

Electricity mistakes and 'nitpicking'
My encounters with elementary-school electricity, and how I started my "electricity debunking" articles.

"Static" sparks
Doorknob sparks and zapping yourself on the car door... and people who suffer from an "electric shock" disease.

Explaining "electricity" visually
A simple classroom activity using red and green plastic sheets. Here's a way to visualize Electric Current, "Static", and the electric charge which creates both.

Right Angle Circuitry
Do Lenz' Law and the Right Hand rule still work... after you've been turned INSIDE OUT by that Evil Grey Fog?

Tesla's Big Mistake
Why did physicists deride Nikola Tesla? What was really going on in Tesla's mind? Some insights...

What is Voltage?
What the heck is VOLTAGE? What the *HECK* is voltage? Charles Fort said that when investigating a circle you can start at any point.

Where does EM energy flow in a circuit?
The schematic of a flashlight looks simple, but only because the electromagnetic energy flow is invisible.

Sparks and Lighting
What would lightning look like if we could slow it down?

How is "static" different from "current?"

Not the usual answer found in most textbooks!

What is the relation between Watts, Ohms, Amps, and Volts?
Trying to tie it all together. Ohm's law and electrical energy.

Electricity is not a form of energy
How can so many textbooks and encyclopedias make a major mistake?

J.C. Maxwell quotes
Maxwell says that electricity is not energy.

"Static Electric" misconceptions
A list of things which gave me a warped view of Electrostatics. Once I recognized their existence, I was able to fight free of them.

Sticky Electrostatics
Use sticky tape to demonstrate the behavior of electric charge.

The "Electricity" Map
How are batteries different than static cling? Perhaps this diagram will "generate" some insights.

Which way does 'electricity' flow?
The direction of the current. Charge really flows from negative to positive, right? RIGHT???

Speed of "Electricity"?
Everyone is sure that charges flow in wires at nearly the speed of light. All the books say so, and that many books can't be wrong, can they? Ah, but science is not settled by voting.

"Acoustimagnetoelectricism"
A long rant about sound, work and electrical energy

Capacitor complaints
Why I never really understood capacitors...

How transistors REALLY work
Problems with traditional transistor explanations...

Why three prongs?
Why do wall outlets have three holes? "Grounding" and safety.

LED explanation
How are Light Emitting Diodes like thermocouples and solar cells?

Are Amperes "Fundamental?"
Everyone learns about "Amps" but never remembers what a "Coulomb" is. This is totally backwards.

Flowing "static electricity."
If "static electricity" could flow along, would the world end? Maybe not...

Discussing Electrical Energy
I'm always getting into flamewars about this stuff...

How *should* we teach "electricity?"
Doing something, rather than just whining. ;)

Why "Electricity" is Impossible to Understand
Gigantic collection of thoughts on learning-barriers in electrical education.

Triboelectric Series
If a cat gets trapped in a clothes dryer full of nylon pantyhose, which way do the electrons flow?

Electricity educational links collection
Part of my Electronics Hobbyist page.

ELECTRONICS HOBBYIST
A whole large pageful of links for the electronics freak. Online discussion groups, schematic and project archives, etc.

Electrical Devices

Electrostatic Loudspeakers
by Mark Rehorst. No magnets, no magnetism, they use voltage-force. Almost like wiggling the air itself.

Ultra-simple Electric Generator
Spin the magnet, light a bulb. The complement to the "Beakman Motor". Challenge: make the one run the other.

Ridiculously sensitive charge detector
Build this simple circuit and detect miniscule levels of electric charge at large distances. Befuddle onlookers with the the "mysterious voice commands" trick by holding it and scuffing your shoes on a rug.

The Duluc Drypile
A "battery" with so many cells that Electrostatic effects appear.

3D E-field viewing bottle
Actually SEE invisible electrostatic fields and magnetic fields by harnessing the amazing powers of Baby Oil.

Dangerous experiments with a big capacitor bank
Nobody died from simply reading this. But stay away from actually performing any of these demos.

Acid/Base Goldenrod secret
Use a battery to draw red lines on wet yellow paper

ELECTROSTATIC GENERATOR, Kelvin's Thunderstorm"
An electrostatic generator based on dribbling water. Also see the INLINE VERSION

VandeGraaff Generators
Instructions for having fun with 500,000 volts, including plans sources, FAQ, debug...

MAGLEV CRADLE
Lifts a bar magnet from below. Use this to perpetrate a Room Temperature Superconductor hoax?

ELECTROSTATIC MOTOR made from plastic pop bottles.
Who says "static electricity" must remain static, or that it's useless and feeble?

ELECTROSTATIC GENERATOR, a simple one
A simple device which can be used to power the pop-bottle motor.

Hints for electrostatic device construction
Building 500,000 volt devices in your basement? Avoid these pitfalls.

Solving Humidity Problems
Egor! Activate the Dehumidifier Array!

ARRAY ELECTROMETER
Build this and SEE electrostatic fields!

VISIBLE CURRENT
This device makes the flowing charges visible in wires. Wouldn't "electricity" be easier to understand if you could SEE it moving?

Plasma Globe with no vacuum pump The Radio Shack "Eye of the Storm" device would be REALLY impressive if it didn't need that glass globe...

Incredibly easy way to make a 100-amp cable. Around the world, the physics teachers look at this and say "Doh!"

Rotating disk device makes e-fields visible
Idea for dangerous whirling mechanisms which reveal invisible field patterns.

ALL ARTICLES ON WEBSITE

SITE MAP

http://amasci.com/ele-edu.html
Created and maintained by Bill Beaty. Mail me at: billb@eskimo.com.
If you are using Lynx, type "c" to email.

THE ATOMS FAMILY

[The Mummy's Tomb](#)

Learn about energy conservation, kinetic, and potential energy.

[The Phantom's Portrait Parlor](#)

Learn about the principles of atoms and matter.

[Dracula's Library](#)

Learn about the properties of light, waves, and particles.

[The Wolf Man's Ghostly Graveyard](#)

Learn about fuel conservation and energy transfer.

[Frankenstein's Lightning Laboratory](#)

Learn about different forms of electricity and electrical safety.

[Navigating this Site](#)

Learn how to explore the resources of this site.

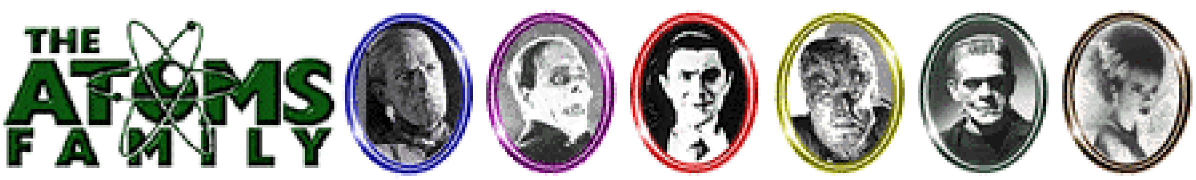
[Credits & Copyrights](#)

The Science Learning Network is made possible by Unisys

[Museum of Science, Inc.](#)/[Science Learning Network](#)

Frankenstein's Lightning Laboratory

- Electrical Safety
  Grades K-6
- Static Electricity
  Grades K-8
- Fruity Electricity
  Grades 4-8



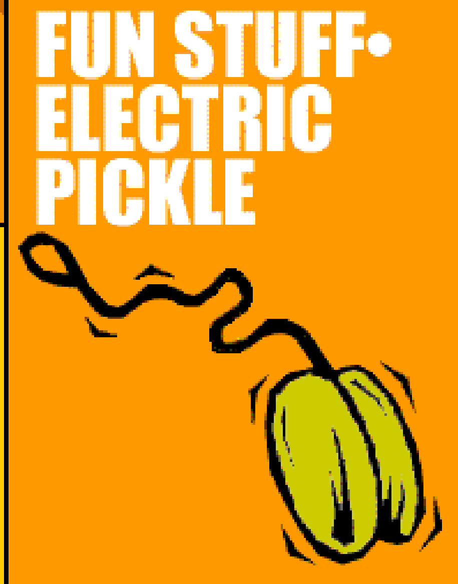
You can buy this resource on CD-ROM for use on computers without internet access.
Visit our **online store** for more information!

The "Bizarre Stuff" kitchen science pages have moved. The new address is (or will be by August 2004)

http://bizarrelabs.com

Please update your favorites and notify the administrator of the website providing this link.

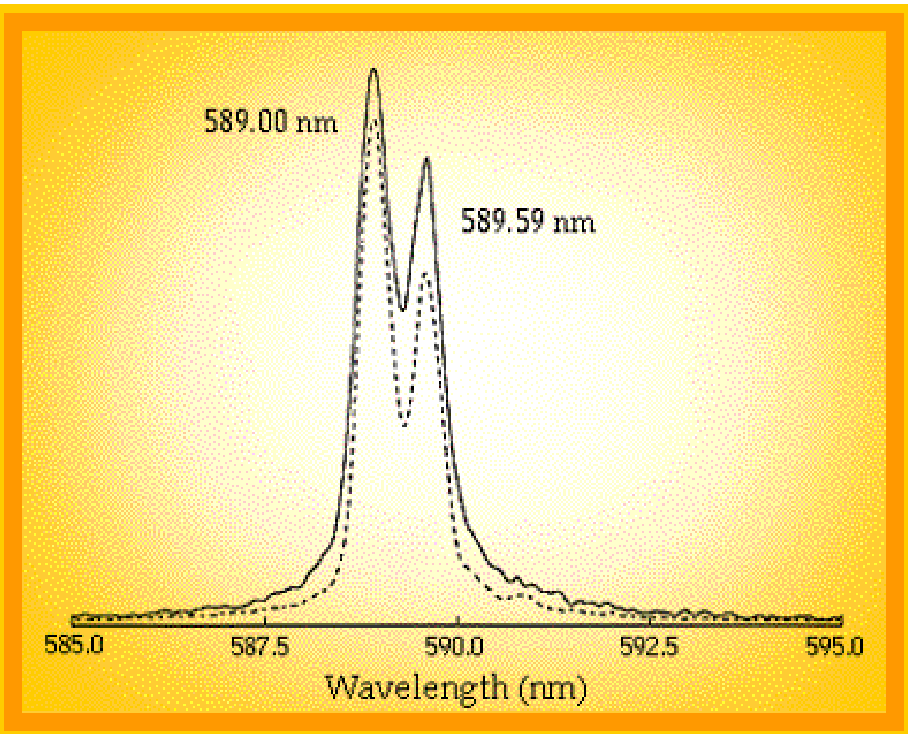
Thank you for your continued support.



Home Page for Electric Pickle

See what happens when you overload your pickle? Why would someone plug a dill pickle into electricity in the first place? A credible story comes from Steve Jacobs, a science educator, creator of the Jake's Attic TV show, and consultant to Mr. Wizard. According to Mr. Jacobs, while attending a garden party during a teacher's conference someone mentioned how they used to cook food in their college dorm with raw electricity (hot plates were either banned or unavailable). Someone at the party then suggested that the host allow a few electrical experiments to various things found around the kitchen. Apparently, glowing dill pickles were the only exciting discovery.

Jacobs worked up the trick for Don Herbert (Mr. Wizard) to perform on The Tonight Show with Johnny Carson on January 24, 1990. On that show Mr. Wizard said he wasn't exactly sure why the pickle glowed yellow when electrocuted. A Discover Chemistry Challenge! Yours truly (J. R. Appling) saw that show and the next morning did an experiment to prove that it is the sodium in the pickle that gives the characteristic yellow glow.



The experiment was performed by taking a visible light spectrum of the glowing pickle, using a Jarrell-Ash spectrograph with a diode array detector. A fiber-optic probe was used to channel the yellow glow to the spectrograph. A calibration spectrum was taken of a sodium chloride flame test. The emission spectra of the two are identical as you can see in the figure (the dashed line is the NaCl flame test, and the solid line is the glowing pickle).

This pair of emission lines at 589.00 nm and 589.59 nm is a characteristic of sodium emission, called the sodium D line doublet. Josef Fraunhofer observed these lines in the emission spectrum of the sun, somewhere around 1817. We know now that it is due specifically to an electronic transition of sodium atoms in the gas phase.

The pickle conducts electricity due to the vinegar (acetic acid) and sodium chloride salt used to make it. Sodium ions in the pickle liquid attach electrons from the flowing current. These ions are neutralized electrically, forming excited sodium atoms in two different excited electronic states (hence the emission doublet).

$$\mathrm{Na}^{+}(aq) + e^{-} \rightarrow \mathrm{Na}^{*}(g)\left[{}^{2}\mathrm{P}_{1/2}\ {}^{2}\mathrm{P}_{3/2}\right] \rightarrow \mathrm{Na}\,(g)\left[{}^{2}\mathrm{S}_{1/2}\right]$$

Because of the heat and sparks and general pandemonium around the electrodes stuck in the pickle, these sodium atoms are in the gas phase. They emit yellow light as they relax to the ground state. The explanation of the phenomenon was first published by J. R. Appling, F. J. Yonke, R. A. Edgington, and S. L. Jacobs as "Sodium D Line Emission from Pickles" in *The Journal of Chemical Education*, vol. 70, no. 3, p. 250 (1993).

Scot Morris published a description of the Electric Pickle in the Games column of *Omni* magazine. He also appeared in the May 13, 1991 edition of *The San Diego Union* newspaper holding an electrocuting pickle by its tail. Penn and Teller also published a description of the Electric Pickle in their book "Penn and Teller's How To Play With Your Food."

Links
Here are some interesting links for the Electric Pickle:

- Organic Illumination Systems. Those wacky guys at Digital published a report.
- Lori's Chemistry Page. Good pictures of flame tests and a movie of the pickle doing its thing. She doesn't give us credit, and gets the citation to the paper wrong, but hey, she's got the movie (868K) and we don't.
- Bizzare Stuff. A short description, nice site for kookie stuff.

Other relevant links:

- Atoms. The Discover Chemistry topic on Light is in the Atoms section.
- Light. More about light on the Discover Chemistry Light and Energy page.
- Bioluminescence. Learn about light emitted from biological things on the Discover Chemistry Bioluminescence page.
- Kitchen Chemistry. More fun things to do in the kitchen, some less dangerous than the Electric Pickle.

ELECTRICITY AND MAGNETISM

TABLE OF CONTENTS

This is a series of experiments about electricity and magnetism that was designed for use in the fourth grade.

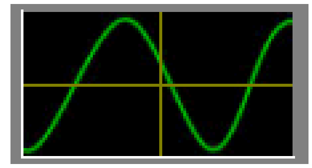
TEACHER'S NOTES | MATERIALS | REFERENCES

THE EXPERIMENTS

Go To The *Hands-On Technology Program* Home Page

Last Update: March 31, 2000

Basic Electronics, Part 2
Elements of AC Electricity



We have made some improvements, and this page is now obsolete.

You should be transferred to the new Table of Contents in about 15 seconds.

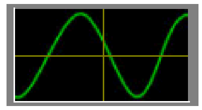
If that doesn't happen, try going directly to the new page at

www.sweethaven.com/acee/forms/coursemain.asp

Be sure to change your bookmark accordingly

SweetHaven Publishing Services

Basic Electronics, Part 2
Elements of AC Electricity



Another SweetHaven Interactive Tutorial

Course Table of Contents

FEEDBACK

You are now viewing the complete, general subject outline for SweetHaven's ***Elements of AC Electricity*** (ACEE), Part 2. Modules that are underlined are currently available, free of charge, for your use. Others are temporarily closed for clean-up or revision.

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You'll find these pages to be full of interesting information that can help you in and out of class:

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The story of how electricity arrives at your home

The water around us:
Interesting facts about the desert's most precious resource

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Power and water safety:
How to stay safe

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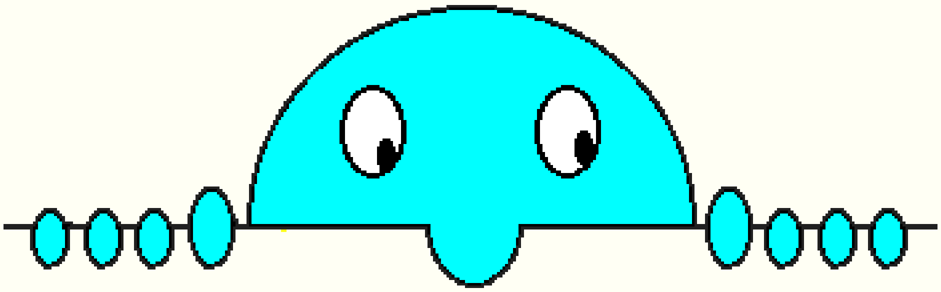
U.S. Department of Energy

SMILE PROGRAM PHYSICS INDEX

The SMILE website is hosted by the Illinois Institute of Technology



The following is a collection of almost 200 single concept lessons. These lessons may be freely copied and used in a classroom but they remain the copyright property of the author(s) and the directors of the SMILE program.

The Physics lessons are divided into the following categories: Matter, Mechanics, Fluids, Electricity & Magnetism, Waves, Sound and Optics, and Miscellaneous.

Matter

- Introduction to the Periodic Table by Estellvenia Sanders - Chicago Vocational
- Tempting Temperatures by Marjorie Fields - Ella Flagg Young
- Air: Demonstrating Its Presence and Effects by Porter Johnson - Illinois Institute of Technology
- Density by Marilyn Martello - Clinton
- Air Movement by Lisa C. Ingram - Frederick Douglass Middle Academy
- Gases Lighter and Heavier than Air by Bonnie Anderson - Libby School Annex
- States of Matter by Kathleen Moore - O. W. Holmes
- Temperature by Jackie Baker - Crown Community Academy
- Exploring the Properties of Matter in the Preschool by Lorraine Watt - Brian Piccolo Elementary School
- The Air Out There by Gladys Allen - Louis Wirth Experimental School
- Comparing Densities of Different Liquids by Elaine Messal - Henry Clay Elementary
- The Three States Of Matter by Sharon R. West - Edward Hurley
- Solids, liquids and gases by Donna Armstrong - Frazier Elementary
- Density in Relation to Float and Sink by Carolyn C. Roberson-Ellis - Morton Career Academy

Mechanics

- Gravity Lesson by Leticia Rodriguez - Ferdinand W. Peck
- The Great Tin Race by Bernina L. Norton - Abbott School

- Tops by Sandra Tucker - Crown Fine Arts Academy
- Periodic Motion - The Pendulum by Deborah Lojkutz - Joliet West High School
- Inertia by Peter Insley - Retired
- Rockets by Rochelle Ingram - Delano School
- Weightlessness by Cynthia D'Souza - De La Salle Institute
- Simple Machines by Bonnie Anderson - Libby School Annex
- Vectors by Eileen Wild - Retired
- Inertia by Maeola Walker - Chicago Board of Education
- Torque by Larry L. Smart - Helen Hefferan Elem.School
- Give Me Energy by April Luehmann - Zion Lutheran School
- Newton's Third Law of Motion by John E. McCoy - Douglass Math and Science Academy
- Pendulums by John J. Miller - Maine East High School
- Bouncing Balls by Porter W. Johnson - Illinois Institute of Technology
- Friction - What a Drag by John J. Miller - Maine East High School
- Momentum Conserved by Savannah Walker - Mason School
- Momentum And Colliding Spheres by Robert Watkins - Beethoven Elementary School
- Straight Line Motion with a Stomper by Ann Brandon - Joliet West High School
- Periodic Motion - The Pendulum by Deborah Lojkutz - Joliet West High School
- Why Use Seat Belts? by Larry Brandon - Thornwood High School
- Reaction Time by Roy Coleman - Morgan Park High School
- Projectile Motion by Jan Dudzik - Riverside-Brookfield High School
- Sports in Physics: Measuring Velocity in a Mini-Olympics by Marion T. Hill - Disney Magnet School
- So You Want to Hit a Home Run? by Karlene Joseph - Walther Lutheran High School
- Center of Gravity by Minnie E. Bounds - Dyett Middle School
- Friction by Kathleen Cummings Dominguez - Sabin Magnet
- Circular Motion: by Jan Dudzik - Whitney Young H.S.
- Rolling Spheres on Inclined Planes by Kenneth Guzik - O.A. Thorp Scholastic Academy
- Orbital Motion by Eleanor Kopsian - Franklin E. Frazier
- Positioning the Fulcrum in Class One Levers by Janis Gary Sullivan - A. O. Sexton School
- Action and Reaction by Mitzie Wilkins - Enrico Fermi Elementary School
- Rotational Inertia by Corla Jean Wilson-Hawkins - Bethune Elementary School
- Projectile Motion (or You Bet Your Grade) by Roy Coleman - Morgan Park High School

- Friction by Jim Szeszol - Mendel Catholic High School

Fluids

- The Bernoulli Effect - Conceptually by Earl Zwicker - Illinois Institute of Technology
- Surface Tension by Pamela S. Moy - Morgan Park High School
- Compared to What? Comparing the Density of Different Liquids by Camille Gales - Coles Elementary School
- Buoyancy: What will float and what will sink by Suzzanne' O'Quinn - Phillips Alternative High School
- Air Pressure by Brian Cagle - John W. Cook
- Buoyant Force by Thomas J. Billups - Delano Elementary
- Do You Sink or Float? by Jackie Baker - Crown Community Academy
- Bernoulli Effect by Michael McIntosh - Whitney M. Young Magnet High School
- Bubbleology Mickey Mouse Style by Paula Z. Jones - Black Magnet
- Pressure in Fluids by Porter W Johnson - Illinois Institute of Technology
- Surface Tension by Lisa C. Ingram - Frederick Douglass Middle Academy
- Displacement by Thomas J. Billups - Delano Elementary
- Sinking And Floating by Tunya Alexander - Frank L. Gillespie School
- The Unmixables: Investigating Immiscible Liquids by Joyce Cohen - Shakespeare-Elementary School
- Surface Tension by Amina Grant - Shakespeare
- Viscosity by Gale Hunter - Dyett Middle School
- Does AIR Really Exist? by Elyse Futterman - Bernard Zell Anshe Emet Day School
- Air Pressure by Gloria Heard - Willams Carter
- Air Pressure by Allen, George - Austin Community Academy
- The Pressure Of A Liquid by Bradley, Patricia - John Hope Community Academy
- Liquid Conductors by Perry, Jean M. - Oakton Elementary School
- Liquid Pressure by Johnson, Leon - D. H. Williams Elementary School
- Bathtub Physics - Density, Buoyancy and Flotation by Russell, Renee - South Shore High School
- How To Make Water Run Uphill by Edgar Boyd, Dorothy Foreman and Earnest Garrison

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Electricity & Magnetism

- Fish and Clip by Winnie Koo - Ravenswood School
- Series and Parallel Circuits by Janet M. Sheard - West School
- Simple Circuitry and series circuit by Stephen W. Ha - James Ward School
- About Magnets by Barbara J. Baker - Doolittle West School
- Magnet Muscles by Deborah Barnes - Robert H. Lawrence School
- Electrostatics by Alyce Glauner- Community Academy
- Electrostatics by Jan Dudzik - Riverside Brookfield High School
- Batteries and Bulbs by Beverly Gregor - Oglesby School
- Electromagnets by Shirley Porter-Cesair - Charles R. Henderson
- Electromagnets by Tanya English - O'Keeffe Elementary School
- Electrostatics by John J. Miller - Maine East High School
- Introduction To Magnets by Sheila McKinnon - Sherman School
- Electricity by Tanya English - O'Keeffe Elementary School
- Electricity by Julian Levey - Teachers Acad. for Math and Science
- Resistances In Series And Parallel Circuits by Austin E. Barnett - Bogan High School
- Magnets, Electromagnets & Fields of Force by John J. Czerwiec - Kenwood Academy

How Smart Are You About Electricity,

- Batteries And Conductors? by Lorraine Epps - Douglass Math and Science Academy
- Introduction to Elementary Circuits by Michael D. Jackson - W.H. Carter
- Electricity by Marie McCadd - Coles Elementary School
- Magnets, Electromagnets, and Motors by Lynne Nolan - Naperville Central High School
- Magnets by Hoi Huynh - Clemente Community Academy
- Exploring Series and Parallel Circuits by Pamela Schneider - Luther East High School
- Magnets by Mina Valenzuela - O. A. Thorp Scholastic Academy
- Electron Current Flow by Greg Zipprich - Bloom Trail High School
- Conductors and Insulators by Leona Williams - Cregier Vocational High School
- Ohm's Law by Anderson, Herbert D. - Hermann Raster Elementary School
- Electric Currents and Circuits by Williams, Claudette - Dever Elementary School
- Magnetism by Gilmore, Marie - Raster School
- What Is Electricity by Oldenburg, Albert - Lindblom Tech High School
- The Millikan L'Eggs Experiment by Coleman, Roy - Morgan Park High School
- Electrochemistry by Allen, Donna L. - Bowen High School
- Electric and Magnetic Fields by Garrison, Earnest S. - Schurz H.S.

- Current-Carrying Coils In Magnetic Fields by Landato, Janet - St. Viator High School
- Coulomb's Law by Austin A.Winther - Paul Robeson High School

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Waves, Sound and Optics

- Sound: The Vibration of Materials by Camille Gales - Coles Elementary
- Now Hear This! by Juliette M. Walker - Crown Community Academy
- Let There be Light by Cheryl Pitts - Crown Academy
- Mixing Primary Colors by Pamela Lopez - Betsy Ross Elementary School
- Light and Vision by Nathaniel M. Brown Jr. - Robert Fulton Elementary School
- Polarization of Light by D. James Chichester - Lincoln-Way High School
- Light by Winnie Koo - Ravenswood School
- Mixing Colors With Light Beams by Angela President - Chicago Public School
- Sound by Winnie Koo - Ravenswood School
- Polarized Light by Scott R. Welty - Maine East High School
- Sound by Christine Scott - Beethoven School
- Color by Cecelia Brown - Anton Dvorak Specialty Academy
- Sound by Kathleen Moore - O. W. Holmes
- Lenses by Carol Bible - Carter Elementary
- Mirror Symmetry/Mirror Images by Alan Tobecksen - Henry Clay Elementary School
- Color by Sandra E. Broomes - Sherman
- Light by Ozell Bonds - Ignace Paderewski School
- Make Waves by Carol Bible - Carter Elementary
- Homemade Instruments by Clara Williams - Douglass Math and Science Academy
- Understanding Waves by Renee Allen - Louis Wirth Experimental
- Making Sounds by Bettye J. Banks - Horace Mann Elementary School
- Light - Reflection - Illusion by George Brydie - Edward White School
- Sound by Anne Chamberlain - Bethune Elementary
- An Awareness Of Light Made Simply Fun by Marian Hunter - Morrill Elementary School
- Pitch by Rosalyn Winston - Walt Disney Magnet
- Plane Mirror Images by Ann Brandon - Joliet West High School
- Hear The Light? by Jane F Long - McAuliffe Elementary
- Comparison of Images Formed by Plane, Cylindrical and Spherical Mirrors by Jim Szezol - Naperville High School

- I Can See A Rainbow! by Lorraine I. Crump - Lawndale Community Academy
- You may now enter the Holodeck. by April Luehmann - Zion Lutheran School
- Sound by Cynthia R. Newman - Washington Elementary
- Sound/Pitch by Joan Cwiklik - O.A. Thorp Scholastic Academy
- Reflection Relay by Lillian Degand - Peterson Elementary
- Wave Motion by Susan Frazier - Fort Dearborn Elementary
- How Sound Travels by Joyce Janovec - St. Gelasius
- Mystery of the Mirrors by Lyvonia Hearns - A. Philip Randolph
- Light by Pennie Machnick - Dirksen School
- Light And Color by Lillie Mae Rayborn - John D. Shoop School
- Spherical Mirrors by Bryan, Bill - Joliet Catholic H.S.
- Polarized Light by Springer, Ellen - Nazareth Academy
- Colors by Schaumburg, Carl - Von Stueben MSC
- Reflections Of by Fowler, Elva House - Cook Elementary School
- Polarization by Hasegawa, Harry - Lawndale Community Academy
- Waves by Johnson, Levi - James Otis
- Guitar Waves by Kulak, Tim - Thornwood High School
- From Vibration To Sound by Persons, Pamela - Walt Disney Magnet School
- Comparison of Images Formed by Plane, Cylindrical and Spherical Mirrors by Springer, Ellen - Nazareth Academy
- Alternate Theory of Color Perception by Szeszol, Jim - Naperville Central H.S.
- Microscopes and Telescopes by Vanderjack, Karisa - Dwight D. Eisenhower H. S.
- Optical Illusions by Boyd Edgar - F.L.Gillespie
- Reflections With Mirrors by Rubalcaba, Antoinette - Inter-American Magnet School
- Color Mixing by Springer, Ellen - Nazareth Academy
- Comparison of Images Formed By Plane and Curved Mirrors by Ellen Springer, Robert Tisdale, Levi Johnson and Alex Economou
- Laser Holography by Carol Zimmerman - Hyde Park Career Academy
- Computer Interfacing: Frequency Measurement - The Doppler Effect by John Bozovsky - Bowen High School

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Miscellaneous

- The Pythagorean Puzzle by Earl Zwicker - Illinois Institute of Technology - Dedicated to Prof. Harald Jensen, Lake Forest College

- Vectors Via the Calculator (For Non-Math Students) by Junievicz, Alex - Gordon Tech
- Calorimetry by Martin, Daniel - Chicago H.S. for Agricultural Sciences
- 10^Huh? by Coleman, Roy - Morgan Park High School
- To Construct An "ALTITUDE LOCATOR" To Find Various Heights by Desai, Jyotiben - Schurz High School
- Measurement by Johnson, Levi - James Otis Elementary
- Using A Video Camera In the Physics Classroom by Skalinder, Eric - Francis W. Parker
- A Potpourri of Science Ideas - Finding Pi by Group Mini Teach by Foreman, Dorothy - Joplin School
- Computerized Problem Review by Group Teach by Donna Allen, Joytiben Desai and Albert Oldenburg
- An Alternative Temperature Measurement by V. K. Brown - Lindbloom T. H. S.
- Persistence Of Vision by Rudy Keil - Schurz High School

Back to the SMILE home page.

The Exploratorium Science Snacks

Snacks about Electricity

Electricity

Snack name	Description
Charge and Carry	Store up an electric charge, then make sparks.
Circles of Magnetism I	You can make a magnetic field that's stronger than the earth's!
Circles of Magnetism IV	Two parallel, current-carrying wires exert forces on each other.
Eddy Currents	A magnet falls more slowly through a metallic tube than it does through a nonmetallic tube.
Electrical Fleas	Start your own electric flea circus!
Electroscope	What's your (electrical) sign?
Hand Battery	Your skin and two different metals create a battery
Magnetic Pendulums	Copper coils become electromagnetic swings.
Magnetic Suction	This experiment shows how your doorbell works.
Motor Effect	A magnet exerts a force on a current-carrying wire.

Short Circuit	What happens when you blow a fuse?
Stripped Down Motor	As motors go, this is about as simple as it gets.

EXPLORATORIUM SNACK HOME PAGE

ELECTRICITY ARTICLES MAIN PAGE GOOD STUFF NEW STUFF SEARCH

"Static Electricity" Page

Articles here:

- "Static electricity" really means "High Voltage"
- Doorknobs, Car-door sparks, electric people
- Explaining "static electricity" with colored plastic sheets.
- "STATIC ELECTRIC" MISCONCEPTIONS
- Electrostatics books
- Sticky Electrostatics: adhesive tape experiments
- The Electricity Map
- What A Shocking Career
- Threadlike streams of "electric wind"
- Static Electricity versus Current Electricity
- Nanoamp current meter
- Hints for electrostatic device construction
- Negative Ion Generator as HV power supply
- A Bit About Wimshurst Machines
- Triboelectric Series, rubbing fur on plastic
- The Duluc Drypile where batteries meet "static"
- "Zerostat" record-cleaner gun
- Solving Humidity Problems
- Sparks and lightning
- Flowing "static"
- Crackpot musings: charged air phenomena
- Tesla Coils, more high voltage
- HV Plasma Globes
- Electronics Hobbyist Page

Billb's HV Build-it Projects:

- VandeGraaff Generator Page
- Ridiculously Sensitive Charge Detector
- ELECTROSTATIC MOTOR made from plastic pop bottles.
- ELECTROSTATIC GENERATOR, electrophorus, a simple one
- ELECTROSTATIC GENERATOR, "Kelvin's Thunderstorm"
- ELECTROSTATIC GENERATOR, In-line waterdropper
- SEE electric and magnetic fields with this simple viewing bottle
- ARRAY ELECTROMETER makes e-fields visible
- Commercial Source for electrostatic generators (kit or assembled)
- All electricity articles here

SCROLL DOWN FOR LOTS MORE LINKS

High Voltage Ring
[Previous | Previous 5 Sites | Next 5 Sites | Next]
[Random Site | List Sites]
[High Voltage Ring]

Highly recommended: ELECTROSTATICS by A. D. Moore (lots of projects)

Projects elsewhere:

- The Amateur Scientist: electrostatic motors
- M. Foster's Cheap High Voltage
- Teralab Electrostatics
- Bob's High Voltage site
- Marx Generators from Mike's Electric Stuff
- RA Morse: Electrostatics Activities for Students
- La construction de la machine de Wimshurst (en français)
- CURIOUS KIDS Static Electric activity
- Nova: indoor lightning
- Op-amp electrometer, R. Hull
- Nat's homebuilt electrostatic generators
- Storm Detector
- Electrostatics projects at "solaris"
- Rubbing Teflon, story from Pease Porridge
- Electrostatic Loudspeaker Project
- Exploratorium demos
- U. Rochester Demos
- Simple Generator from Leny R's SPARK, BANG, BUZZ
- Generators by G. Shannon
- Highway to Science activities

- Demos links at J. of Electrostatics
- Boston MOS static activities

Forums

- alt.energy.high-voltage
- Electrostatics Soc. of America
- Sam's Powerlabs
- High Voltage list (archive 1996-pres)
- HV Assn forum
- VDG vorum

Websites elsewhere:

Resources

- DMOZ: High Voltage
- Electrostatic Machines
- Sparkmuseum electrostatic machines
- Electrostatics Glossary from (ESD Journal)
- High-volteage Handbook
- Matweb (capacitor dielectric search!)
- Dielectric Constants (list)
- Mr. Static FAQ
- FAQ Page: Problems caused by "Static"
- Static elim. companies
- Book Catalog fm/EAI

Organizations

- Electrostatics Society of America
- Journal of Electrostatics and index
- ESD Journal
- Electrostatics Webring

LINKS

- Steam-jet electrostatic generator
- Electro-magnetic Miscellany
- Spark ignition of solvent, CE mag

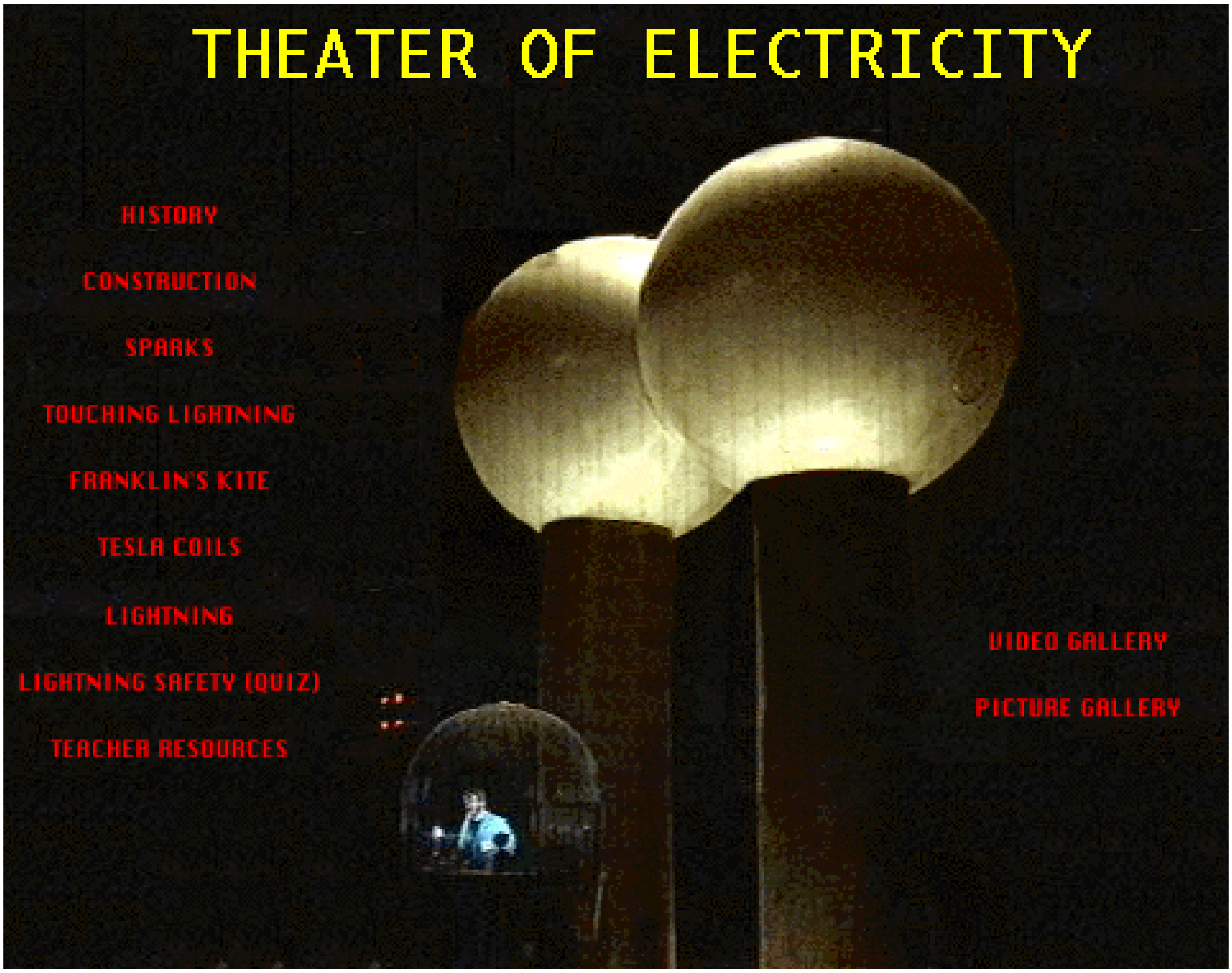
- Dave Swenson's Hair-raising Tales
- Priestly's Physics Project, activities from Franklin Inst.
- Carbon fiber tape (good for discharge brushes)
- Electrostatic Cooling
- Zerostat(r) gun , also here
- Scams and "health claims"
    - Cordless grounding straps
    - Mr. Static: Static Hocus-Pocus
    - Ground yourself during sleep for $330?
- VDG & electrostatics forum
- Video: aircraft lightning strike
- Electric Snowflakes
- Lightning Webring
- Gas Station Static Fires
    - Articles from ESD journal
    - Chevron warning
    - PEI Letter
    - Fire report summary
    - Gas can fires
- Clarendon Dry Pile, "perpetual motion" that works
- The Bakken Museum & Library, historical electrical devices
- ELECTROSTATICS by A. D. Moore now in reprint
- Car door sparks: The Control of Body Voltage Getting Out of a Car
- The Control of Static Electricity
- Electrostatics Applications Inc. (electrostatics books)
    - Links Collection fm/EAI
    - Book Catalog fm/EAI
- PIRA's list of Electrostatic Physics Demonstrations
- Historical Electrostatic Machines, Polytechnique, France
- "Power fence" wind power
- NCSSM Electrostatics Lab Activity
- TSU Maryland VDG demos
- Electrostatic machines list from NCSU

- Electrostatic, U. Virginia
- Lorente's generator
- Condensation causes electrification??!
- Negatively charged air
- Giant VDG in Boston
- Giant VDG in Boston, History
- A VDG project

Some Companies

- Sensitive Research, electrostatic voltmeters (passive, moving-plate electrometer)
- High Voltage Association company & products links
- Professional voltmeters, power supplies, etc.
- Surplus Sales, HV connectors, also MHV
- PV Instruments: electrostatic machines
- Resonance Research, VDG machines & tesla coils
- Monroe Electrostatics
- Simco
- Trek Electrostatic Voltmeters
- Novx Corp
- J Chubb Inst. (UK)
- Kinderprint fingerprint kits
- Ion Systems

Created and maintained by Bill Beaty. Mail me at: billb@eskimo.com.
If you are using Lynx, type "c" to email.



[HISTORY | CONSTRUCTION | SPARKS | TOUCHING LIGHTNING | FRANKLIN'S KITE | TESLA COILS | LIGHTNING | SAFETY QUIZ | TEACHER RESOURCES | VIDEO GALLERY | PICTURE GALLERY]

Activities to explore Static Electricity

- Background Information for Teachers
- Your Admirer is a Balloon
- What Will a Charged Balloon Attract
- Dancing Paper Bunnies
- Static Tubes
- A Simple Electroscope

And an introduction to current electricity

Virtual Labs & Simulations

****** Great Web Sites for Interactive Learning ******
Established: Dec. 27, 1999

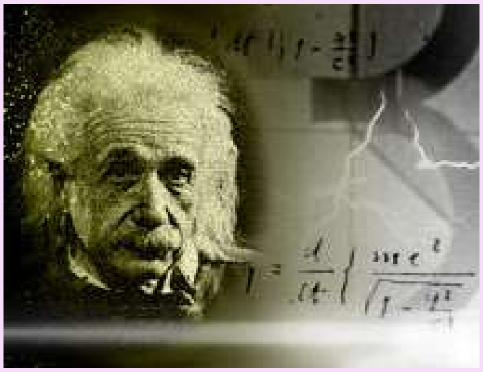
Who Visits this Site?

Virtual Physics Simulations

To view some of the simulation and programs on this site you must have the Macromedia Shockwave Plug-in and/or Adobe Acrobat Reader.

This page is a collection of links to sites on the web that have computerized simulations of physics principles. These might be in the form of a Java Applet, a Shockwave demonstration or an Activity Worksheet, but the basic purpose is the same in all cases: to allow students to see a visual demonstration of a scientific concept, often in animated form. In addition, the student may be given the opportunity to manipulate one or more variables underlying the concept and then witness the changes.

"In the matter of physics, the first lessons should contain nothing but what is experimental and interesting to see. A pretty experiment is in itself often more valuable than twenty formulae extracted from our minds."
- Albert Einstein



Virtual	*Labs*	*and*	*Simulations*
Fundamentals (13 Links)	**Mechanics** (130 Links)	**Momentum** (17 Links)	**Rotational Mechanics** (19 Links)
Machines (9 Links)	**Measurement** (6 Links)	**Fluids** (8 Links)	**Electricity** (62 Links)
Thermodynamics (15 Links)	**Simple Harmonic Motion** (15 Links)	**Waves** (46 Links)	**Sound** (26 Links)
Light (29 Links)	**Light and Optics** (56 Links)	**Color Theory** (20 Links)	**Nuclear** (11 Links)
AstroPhysics (17 Links)	**Math & Computers** (9 Links)	**Chemistry** (10 Links)	**Collections** (24 Links)

email

THE RETURN OF WATT'S ON YOUR MIND?

Teacher's Lounge | About This Site | Front Gate

The New York Times on the Web Learning Network
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[Daily News Quiz]
[Word of the Day]
[Test Prep Question of the Day]
[Web Explorer]
[Science Q & A]
[Letters to the Editor]
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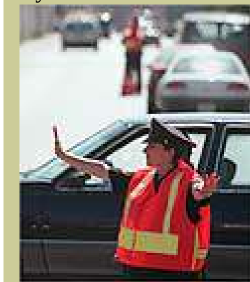
By DAVID BARSTOW



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Thursday, July 8, 1999

Watts Up with the Heat

Building and Understanding Basic Electrical Circuits and Their Practical Applications

Author(s)
[Alison Zimbalist, The New York Times Learning Network]

Grades: 6-8, 9-12
Subjects: Science, Technology
[Interdisciplinary Connections]

Overview of Lesson Plan: In this lesson, students create a variety of simple, series and parallel electrical circuits to illustrate how electricity flows through different types of basic circuits and to understand the practical applications of these types of circuits. Students then apply their knowledge of electrical circuits to the loss of power in the midst of July 1999's heat wave, determining how electrical power systems fail in extreme heat, how 'load shedding' is used to reduce strain on power sources, and how power outages can be prevented in the future.
Review the [Academic Content Standards] related to this lesson.

Suggested Time Allowance: 45 minutes- 1 hour

Objectives:
Students will:
1. Apply their understanding of electricity to create a simple circuit.
2. Apply their understanding of electricity to create a simple circuit with a switch; understand the practical applications of this type of circuit.
3. Determine how added voltage increases the intensity of light from a light bulb; create a simple circuit using two batteries; predict and compare the results of this circuit to the previously-created simple circuits; understand the practical application of this circuit.
4. Apply their understanding of electricity to create a series circuit; predict and compare the results of this circuit to the simple circuits created; understand the practical application of this type of circuit.
5. Apply their understanding of electricity to create a parallel circuit; predict and compare the results of this circuit to the simple and series circuits created; understand the practical application of this type of circuit.
6. Apply their understanding of electricity and electrical circuits to determine how electrical power systems fail in extreme heat, how "load shedding" is used to reduce strain on power sources, and defend ways in which power outages can be prevented in the future.

Resources / Materials:
FOR EACH PAIR OR GROUP OF THREE STUDENTS, prepare a paper bag that contains the following items (all can be purchased cheaply at an electronics store):
-Two C or D batteries (1.5 volts)
-Two battery holders
-One single pole knife switch
-Six pieces of insulated copper wire (6"-8" pieces with the ends stripped of insulation)
-Three flashlight bulbs

Have extra batteries and light bulbs on hand in the event that they should run out.
Additional materials:
-student journals or lab books
-paper
-pens/pencils
-classroom blackboard
-copies of "Heat Sets Records, Claims Lives and Strains Utilities" (one per student)

Activities / Procedures:
NOTE TO TEACHERS: In this activity, students create simple, parallel and series circuits. Please review lab safety rules with students prior to conducting these experiments. You should also create sample circuits prior to class so that you are familiar with what each circuit should look like when built by your students. A physical science textbook should have illustrations of these circuits.

1. WARM-UP/DO-NOW: Prior to class, write the following sentence on the board: You have five minutes to use a battery, a battery holder, a light bulb and two wires to make the light bulb light up. As students arrive in the classroom, divide them into pairs or small groups and give each group a bag containing the batteries, battery holders, light bulbs and wire. Students then follow the directions on the board and create simple circuits. Walk around the room to monitor student progress. After the five minutes are up, ask students the following questions:
--What made the light bulb light up? Where does the electricity come from, and where does it go?
--Why are the ends of each wire exposed and the rest of the wire covered by an insulating coating? (Explain that the metal wire serves as a conductor of electricity.) What other items conduct electricity?
--What happens when a wire is disconnected? (The circuit is broken.)
Explain that this type of circuit is called a simple circuit. Ask students to draw and label their simple circuit in their journal or lab book.

2. Tell students to add the switch in their bag to the simple circuit they just created. How does the switch work? Why doesn't the electricity "jump" over the switch when it is turned off? Where in their homes do students use similar circuits? Students draw and label their simple circuit with the switch under their previous illustration.

3. Now, ask students to create a simple circuit using two batteries, two battery holders, three wires and a light bulb. How do their results differ from the previous simple circuits, and why? Students draw and label this simple circuit under their previous illustration.

4. Ask students to use two batteries, three light bulbs, and five wires to make all three light bulbs light up. (The middle light bulb should be connected to the two outer bulbs and not to a battery.) How do their results differ from the simple circuits that they have already created, and why? What do students think would happen if one bulb was loosened, and why? Students should then loosen a bulb to see that none of the bulbs will work. Where in their homes do students have similar circuits (e.g., strings of lights)? Explain that this is called a series circuit, and ask why this name is appropriate. Tell students to draw and label this circuit under their illustrations of the simple circuits.

5. Tell students that their last challenge is to use one battery, one battery holder, four wires and two light bulbs to light the two bulbs. Instruct students to not connect the light bulbs to each other with a wire. How does electricity flow through this circuit? How does the brightness of each of the two light bulbs compare to the brightness that they saw in the simple circuits and in the series circuit, and why? What do students think would happen if one bulb was loosened, and why? Students should then loosen a bulb to see that the other bulb will remain lit. How does this bulb's brightness compare to the brightness of the two bulbs? What would happen if there were hundreds of bulbs in this circuit connected to this initial battery? What would happen if a switch were placed between each light bulb and the battery? Where in their homes do students have similar circuits (e.g., several appliances connected to one outlet)? Explain that this is called a parallel

circuit, and ask why this name is appropriate. Tell students to draw and label this circuit under their illustration of the series circuit.

6. WRAP-UP/DO-NOW: Students read the article "Heat Sets Records, Claims Lives and Strains Utilities" and answer the following questions in their journals:
--Why did the power system fail in New York and other areas of the United States?
--What type of circuit (simple, series, or parallel) connects electrical power plants to the homes that it serves? Draw an illustration.
--What is "load shedding," and how does it function given this type of electrical circuit?
--Given what you know about electricity and different types of circuits, how can power outages be avoided in the future, particularly in heat waves such as the one described in the article?

Further Questions for Discussion:
--How does electrical power travel from the generating plant to your home?
--What can cause a power outage?
--Why do blackouts so often occur in extreme weather conditions?
--What elements of a household are affected when electrical power is lost?
--What elements of a city's infrastructure are affected in the event of a blackout?
--In what ways can power outages, both in the home and on a larger scale, be prevented?
--How can a person adequately prepare for a blackout?
--How does electricity affect your daily life? How would you accomplish everyday tasks without it?
--What is the importance of energy conservation?
--What alternative forms of energy exist, and what are their benefits and drawbacks?

Evaluation / Assessment:
Students will be evaluated based on the creation of various basic electrical circuits, detailed illustrations of circuits, participation in class discussions, and final written journal response.

Vocabulary:
maddening, overload, fuses, fatalities, conserve, hyperthermia, transformers, arced, circuits, reserves, voltage, strenuous, consumption, meteorologists, compressing, descends, pleas, commercial, residential, prolonged, blackouts

Extension Activities:
1. Further your knowledge of electricity with fun, easy experiments that you can conduct at home (with an adult's help). Check out the variety of experiments available on the Internet, including ProTeacher's Electricity Experiments (http://www.proteacher.com/110016.shtml) and electricity lesson plans from Rutger's University (http://www.physics.rutgers.edu/hex/visit/lesson/lesson_links1.html#ele7).

2. Create an Internet scavenger hunt about heat waves, finding different Web sites that relate to this weather condition and jotting down one question that can be answered by each Web site you find. Then, challenge a family member or friend to answer your questions about heat waves by using your Internet scavenger hunt.

3. Create a "How It Works" poster that explains how transformers, power generators, air conditioners or fans work.

4. Develop a guide to electrical safety, energy conservation, or how electricity works geared toward students your age or younger.

5. Research alternative energy sources and the benefits and drawbacks of each. Create a visual display about one or several of these sources to display in your classroom.

6. Conduct an electricity survey of your home. Create a list of electrical appliances in your home and how much energy they use, learn what items in your home are powered by an energy source other than electricity, and examine your electricity bill to see how much electricity you use in a month compared to the monthly average of your area.

7. Tour your local electrical power plant to learn about how electricity travels to your home.

8. Create a chart that defines and compares various energy and power units, such as horsepower, joules, watts, kilowatts, therms, tons and BTUs. Be sure to include what items each unit powers, as well as how these units of energy got their names.

Interdisciplinary Connections:

Geography/Mathematics- Map and graph weather patterns (temperature, precipitation, fronts, etc.) over the next month or the rest of the season for your state, region or country.

Health- Learn about heat-related illnesses. Then, create a heat safety guide to be used as a reference by your family, class, or school health clinic.

Language Arts- Write a short story beginning with the sentence, "It was the hottest day of the year, and our electricity was out."

Social Studies- Investigate how various elements of a city's infrastructure (commerce/trade, food supply, health care, communication/roads, shelter, power supply) are affected by extreme weather conditions (such as heat waves) or natural disasters.

Other Information on the Web

American Red Cross: Heat Waves (http://www.redcross.org/disaster/safety/heat.html) discusses what a heat wave is, what to do to protect yourself, and how to recognize and treat heat-related health emergencies.

Weather Channel Encyclopedia: Heat Wave (http://www.weather.com/breaking_weather/encyclopedia/heat/) teaches about extreme heat safety, heat climatology, forecasting heat, historical heat waves, the UV index, and droughts.

BrainPop: Electricity (http://www.brainpop.com/electric/) is a fun site about electricity that offers a movie, a quiz, experiments, and much more.

Electricity and Magnetism (http://ippex.pppl.gov/ippex/module_4/) teaches the basic concepts behind these two topics.

The Atoms Family (http://www.miamisci.org/af/sln/) is an information-packed site from the Miami Museum of Science, where you can learn about different types of energy, the properties of light, electricity, atoms, and fuel conservation.

Theater of Electricity (http://www.mos.org/sln/toe/toe.html) offers great info on electricity and the huge Van de Graaff generator at the Boston Museum of Science.

Academic Content Standards:

This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8

Technology Standard 3- Understands the relationships among science, technology, society, and the individual. Benchmarks: Knows that scientific inquiry and technological design have similarities and differences; Knows that science cannot answer all questions and technology cannot solve all human problems or meet all human needs; Knows ways in which technology has influenced the course of history; Knows that technology and science are reciprocal; Knows ways in which technology and society influence one another

Science Standard 13- Knows the kinds of forces that exist between objects and within atoms. Benchmarks: Knows that just as electric currents can produce magnetic forces, magnets can cause electric currents
Science Standard 15- Understands the nature of scientific inquiry. Benchmarks: Knows that there is no fixed procedure called "the scientific method," but that investigations involve systematic observations, carefully collected, relevant evidence, logical reasoning, and some imagination in developing hypotheses and explanations; Designs and conducts a scientific investigation; Uses appropriate tools (including computer hardware and software) and techniques to gather, analyze, and interpret scientific data; Establishes relationships based on evidence and logical argument; Understands the nature of scientific explanations; Knows that scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists
Science Standard 16- Understands the scientific enterprise. Benchmarks: Knows various settings in which scientists and engineers may work; Knows ways in which science and society influence one another

Grades 9-12
Technology Standard 3- Understands the relationships among science, technology, society, and the individual. Benchmarks: Knows that science and technology are pursued for different purposes; Knows that mathematics, creativity, logic, and originality are all needed to improve technology; Identifies the role of technology in a variety of careers
Science Standard 13- Knows the kinds of forces that exist between objects and within atoms. Benchmarks: Knows how different kinds of materials respond to electric forces; Knows that materials that contain equal proportions of positive and negative charges are electrically neutral, but a very small excess or deficit of negative charges in a material produces noticeable electric forces; Knows that magnetic forces are very closely related to electric forces and can be thought of as different aspects of a single electromagnetic force (moving electric charges produce magnetic forces and moving magnets produce electric forces)-the interplay of these forces is the basis for electric motors, generators, radio, television, and many other modern technologies; Knows that electromagnetic forces exist within and between atoms
Science Standard 15- Understands the nature of scientific inquiry. Benchmarks: Understands the use of hypotheses in science; Designs and conducts scientific investigations by formulating testable hypotheses, identifying and clarifying the method, controls, and variables; organizing and displaying data; revising methods and explanations; presenting the results; and receiving critical response from others; Knows that a wide range of natural occurrences may be observed to discern patterns when conditions of an investigation cannot be controlled; Knows that conceptual principles and knowledge guide scientific inquiries; historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists
Science Standard 16- Understands the scientific enterprise. Benchmarks: Knows that throughout history, diverse cultures have developed scientific ideas and solved human problems through technology; Knows tht science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen

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WHAT IS STATIC ELECTRICITY?

by

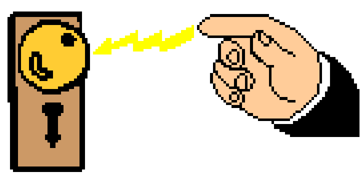
SCIENCE MADE SIMPLE

Science Made Simple / Science Subjects / Science in the News / Measurement Conversions

PO Box 503, Voorhees, NJ 08043

INDEX: What is Static Electricity? --- I Can Read --- Projects
Learn More About: Triboelectric Series, Coulomb's Law

You walk across the rug, reach for the doorknob and..........ZAP!!! You get a shock.



Or, you come inside from the cold, pull off your hat and......BOING!!! All your hair stands on end. What is going on here? And why does it only happen in the winter?

The answer is:

STATIC ELECTRICITY

To understand what static electricity is, we have to learn a little bit about the nature of matter. Or in other words, what is all the stuff around us made of?

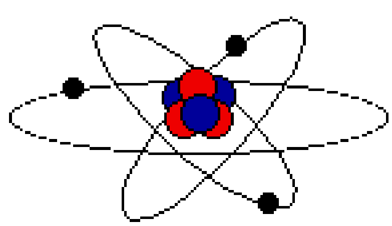
EVERYTHING IS MADE OF ATOMS

Imagine a pure gold ring. Divide it in half and give one of the halves away. Keep dividing and dividing and dividing. Soon you will have a piece so small you will not be able to see it without a microscope. It may be very, very small, but it is still a piece of gold. If you could keep dividing it into smaller and smaller pieces, you would finally get to the smallest piece of gold possible. It is called an atom. If you divided it into smaller pieces, it would no longer be gold.

Everything around us is made of atoms. Scientists so far have found only 115 different kinds of atoms. Everything you see is made of different combinations of these atoms.

PARTS OF AN ATOM

So what are atoms made of? In the middle of each atom is a "nucleus." The nucleus contains two kinds of tiny particles, called protons and neutrons. Orbiting around the nucleus are even smaller particles called electrons. The 115 kinds of atoms are different from each other because they have different numbers of protons, neutrons and electrons.



It is useful to think of a model of the atom as similar to the solar system. The nucleus is in the center of the atom, like the sun in the center of the solar system. The electrons orbit around the nucleus like the planets around the sun. Just like in the solar system, the nucleus is large compared to the electrons. The atom is mostly empty space. And the electrons are very far away from the nucleus. While this model is not completely accurate, we can use it to help us understand static electricity.

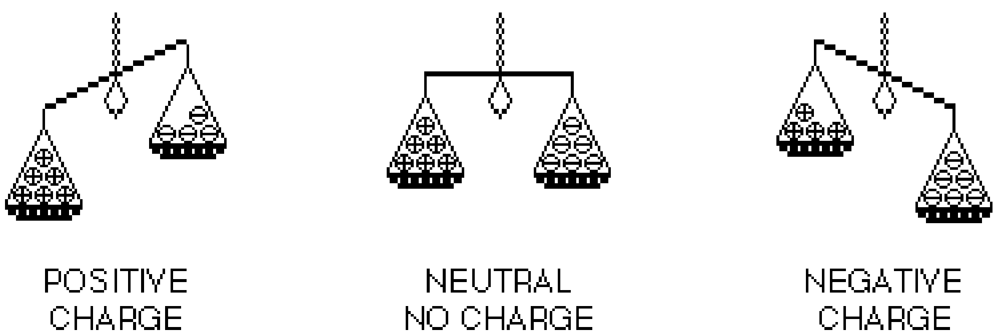
(Note: A more accurate model would show the electrons moving in 3- dimensional volumes with different shapes, called orbitals. This may be discussed in a future issue.)

ELECTRICAL CHARGES

Protons, neutrons and electrons are very different from each other. They have their own properties, or characteristics. One of these properties is called an electrical charge. Protons have what we call a "positive" (+) charge. Electrons have a "negative" (-) charge. Neutrons have no charge, they are neutral. The charge of one proton is equal in strength to the charge of one electron. When the number of protons in an atom equals the number of electrons, the atom itself has no overall charge, it is neutral.

ELECTRONS CAN MOVE

The protons and neutrons in the nucleus are held together very tightly. Normally the nucleus does not change. But some of the outer electrons are held very loosely. They can move from one atom to another. An atom that looses electrons has more positive charges (protons) than negative charges (electrons). It is positively charged. An atom that gains electrons has more negative than positive particles. It has a negative charge. A charged atom is called an "ion."



Some materials hold their electrons very tightly. Electrons do not move through them very well. These things are called insulators. Plastic, cloth, glass and dry air are good insulators. Other materials have some loosely held electrons, which move through them very easily. These are called conductors. Most metals are good conductors.

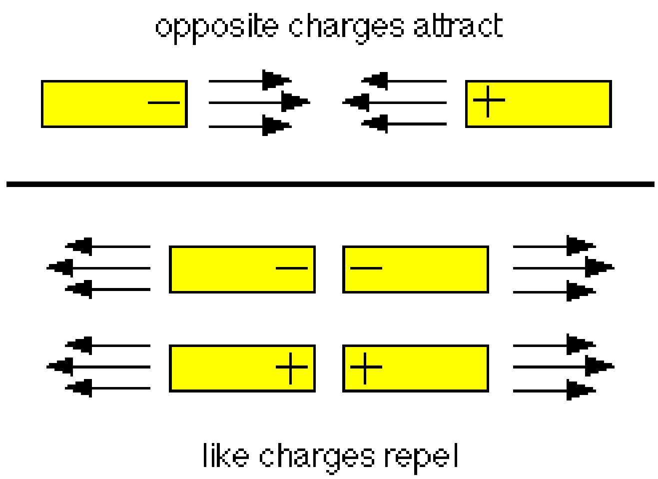
How can we move electrons from one place to another? One very common way is to rub two objects together. If they are made of different materials, and are both insulators, electrons may be transferred (or moved) from one to the other. The more rubbing, the more electrons move, and the larger the charges built up. (Scientists believe that it is not the rubbing or friction that causes electrons to move. It is simply the contact between two different materials. Rubbing just increases the contact area between them.)

Static electricity is the imbalance of

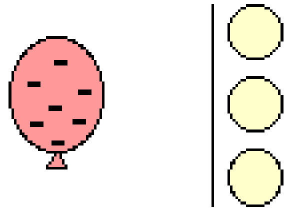
positive and negative charges.

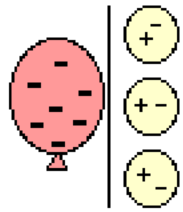
OPPOSITES ATTRACT

Now, positive and negative charges behave in interesting ways. Did you ever hear the saying that opposites attract? Well, it's true. Two things with opposite, or different charges (a positive and a negative) will attract, or pull towards each other. Things with the same charge (two positives or two negatives) will repel, or push away from each other.



A charged object will also attract something that is neutral. Think about how you can make a balloon stick to the wall. If you charge a balloon by rubbing it on your hair, it picks up extra electrons and has a negative charge. Holding it near a neutral object will make the charges in that object move. If it is a conductor, many electrons move easily to the other side, as far from the balloon as possible. If it is an insulator, the electrons in the atoms and molecules can only move very slightly to one side, away from the balloon. In either case, there are more positive charges closer to the negative balloon. Opposites attract. The balloon sticks. (At least until the electrons on the balloon slowly leak off.) It works the same way for neutral and positively charged objects.





So what does all this have to do with shocks? Or hair full of static? When you take off your wool hat, it rubs against your hair. Electrons move from your hair to the hat. Now each of the hairs has the same positive charge. Remember, things with the same charge repel each other. So the hairs try to get as far from each other as possible. The farthest they can get is by standing up and away from the others. Bad hair day!

As you walk across a carpet, electrons move from the rug to you. Now you have extra electrons. Touch a door knob and ZAP! The door knob is a conductor. The electrons move from you to the knob. You get a shock.

We usually only notice static electricity in the winter when the air is very dry. During the summer, the air is more humid. The water in the air helps electrons move off you more quickly, so you can not build up as big a charge.

LEARN MORE ABOUT: STATIC ELECTRICITY

TRIBOELECTRIC SERIES

When we rub two different materials together, which becomes positively charged and which becomes negative? Scientists have ranked materials in order of their ability to hold or give up electrons. This ranking is called the triboelectric series. A list of some common materials is shown here. Under ideal conditions, if two materials are rubbed together, the one higher on the list should give up electrons and become positively charged. You can experiment with things on this list for yourself

TRIBOELECTRIC SERIES

your hand
glass
your hair
nylon
wool
fur
silk
paper
cotton
hard rubber
polyester
polyvinylchloride plastic

CONSERVATION OF CHARGE

When we charge something with static electricity, no electrons are made or destroyed. No new protons appear or disappear. Electrons are just moved from one place to another. The net, or total, electric charge stays the same. This is called the principle of conservation of charge.

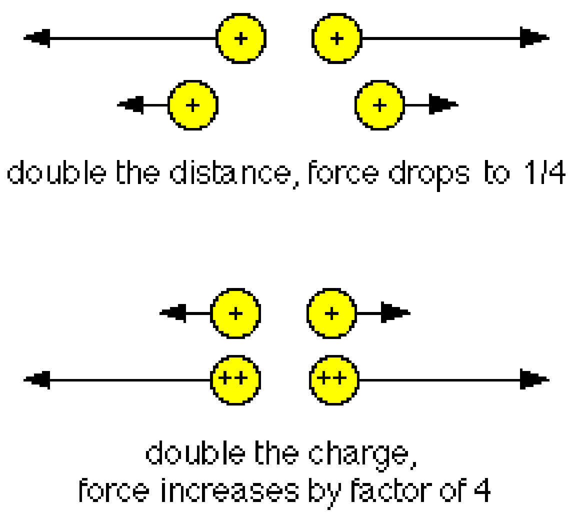
COULOMB'S LAW

Charged objects create an invisible electric force field around themselves. The strength of this field depends on many things, including the amount of charge, distance involved, and shape of the objects. This can become very complicated. We can simplify things by working with "point sources" of charge. Point sources are charged objects which are much, much smaller than the distance between them.

Charles Coulomb first described electric field strengths in the 1780's. He found that for point charges, the electrical force varies directly with the product of the charges. In other words, the greater the charges, the stronger the field. And the field varies inversely with the square of the distance between the charges. This means that the greater the distance, the weaker the force becomes. This can be written as the formula:

F = k (q1 X q2) / d**2

where q is the charge, and d is the distance between the charges. K is the proportionality constant, and depends on the material separating the charges.



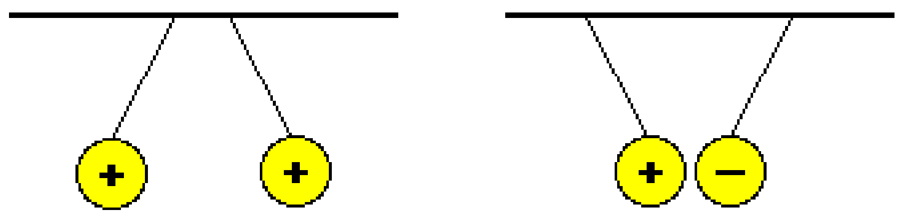
I CAN READ

What is Static Electricity?

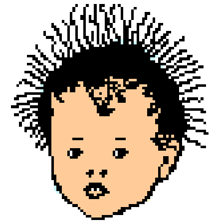
Everything we see is made up of tiny little parts called atoms. The atoms are made of even smaller parts. These are called protons, electrons and neutrons. They are very different from each other in many ways. One way they are different is their "charge." Protons have a positive (+) charge. Electrons have a negative (-) charge. Neutrons have no charge.

Usually, atoms have the same number of electrons and protons. Then the atom has no charge, it is "neutral." But if you rub things together, electrons can move from one atom to another. Some atoms get extra electrons. They have a negative charge. Other atoms lose electrons. They have a positive charge. When charges are separated like this, it is called static electricity.

If two things have different charges, they attract, or pull towards each other. If two things have the same charge, they repel, or push away from each other.



So, why does your hair stand up after you take your hat off? When you pull your hat off, it rubs against your hair. Electrons move from your hair to the hat. Now each of the hairs has the same positive charge. Things with the same charge repel each other. So the hairs try to move away from each other. The farthest they can get is to stand up and away from all the other hairs.



If you walk across a carpet, electrons move from the rug to you. Now you have extra electrons. Touch a door knob and ZAP! The electrons move from you to the knob. You get a shock.

PROJECTS TO DO TOGETHER

SAFETY NOTE: Please read all instructions completely before starting. Observe all safety precautions.

Tip: Try to use the part of the charged object that has the biggest charge (the part that was rubbed the most) when doing these experiments. Also, Projects 1-3 work best on dry days.

PROJECT 1 - Swinging cereal

What you need:

a hard rubber or plastic comb, or a balloon

thread, small pieces of dry cereal (O-shapes, or puffed rice of wheat)

What to do:

1. Tie a piece of the cereal to one end of a 12 inch piece of thread. Find a place to attach the other end so that the cereal does not hang close to anything else. (You can tape the thread to the edge of a table but check with your parents first.)
2. Wash the comb to remove any oils and dry it well.

3. Charge the comb by running it through long, dry hair several times, or vigorously rub the comb on a wool sweater.
4. Slowly bring the comb near the cereal. It will swing to touch the comb. Hold it still until the cereal jumps away by itself.
5. Now try to touch the comb to the cereal again. It will move away as the comb approaches.
6. This project can also be done by substituting a balloon for the comb.

What Happened: Combing your hair moved electrons from your hair to the comb. The comb had a negative charge. The neutral cereal was attracted to it. When they touched, electrons slowly moved from the comb to the cereal. Now both objects had the same negative charge, and the cereal was repelled.

PROJECT 2 - Bending water

What you need:

a hard rubber or plastic comb, or a balloon

a sink and water faucet.

What to do:

1. Turn on the faucet so that the water runs out in a small, steady stream, about 1/8 inch thick.
2. Charge the comb by running it through long, dry hair several times or rub it vigorously on a sweater.
3. Slowly bring the comb near the water and watch the water "bend."
4. This project can also be done with a balloon.

What happened: The neutral water was attracted to the charged comb, and moved towards it.

PROJECT 3 - Light a light bulb with a balloon

You Need:

hard rubber comb or balloon

a dark room

fluorescent light bulb (not an incandescent bulb)

SAFETY NOTE: DO NOT USE ELECTRICITY FROM A WALL OUTLET FOR THIS EXPERIMENT. Handle the glass light bulb with care to avoid breakage. The bulb can be wrapped in sticky, transparent tape to reduce the chance of injury if it does break.

What to do:

1. Take the light bulb and comb into the dark room.

2. Charge the comb on your hair or sweater. Make sure to build up a lot of charge for this experiment.
3. Touch the charged part of the comb to the light bulb and watch very carefully. You should be able to see small sparks. Experiment with touching different parts of the bulb.

What happened: When the charged comb touched the bulb, electrons moved from it to the bulb, causing the small sparks of light inside. In normal operation, the electrons to light the bulb come from the electrical power lines through a wire in the end of the tube. (Fluorescent and incandescent light bulbs will be discussed in a future issue.)

PROJECT 4 - Static in the Summer

What you need:

a balloon, and a watch or clock

What you do:

1. Rub the balloon on your hair or sweater. Stick it to a wall and time how long it stays before falling down.
2. Repeat step (1) in the bathroom, just after someone has taken a hot, steamy shower.

What happened: In the bathroom, water in the air and on the walls helped move electrons away from the balloon more quickly. In the summer, the air is more humid, and static electricity does not build up as much as during the winter, when the air is very dry.

SUBSCRIPTION INFORMATION

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Bowden's Hobby Circuits

A small collection of electronic circuits for the hobbyist or student. Site includes over 100 circuit diagrams, links to related sites, commercial kits and projects, newsgroups and educational areas. Most of the circuits can be built with common components available from Radio Shack or salvaged from scrap electronic equipment. Most all of the circuits have been built and tested and believed to perform as described, however possible mistakes may be found.

Additions and Corrections (12/04/03)

Digital/Computer

- 16 Bit PC Serial Port Receiver (CMOS)
- 24 bit ISA card Installs into your computer. Parts, plans, schematics and programmng available. Also may be purchased as a kit.
- 32 Bit Serial Receiver (57.6 K Baud TTL & CMOS)
- Parallel Port Relay Interface Circuit
- Reading Data From The Parallel Port
- 1 Second Time Base From Crystal Osc.
- 32.768 KHz Oscillator Using A Common Watch Crystal
- Digital Electronic Lock

Telephone Circuits

- Use Old Telephones as Intercom

Power Circuits

- Simple Variable Voltage Source
- LM317 Variable Voltage Regulator
- LM317 Regulator With Pass Transistor

LED Circuits

Miscellaneous

- LED Battery Condition Indicator
- 8 Stage LED VU Meter
- Battery Equal Charge Indicator
- IR Remote Control Tester
- AC Line Powered LEDs
- LED Traffic Lights

Analog / RF Circuits

- LED Decibel Meter
- Whistle On - Whistle Off
- Long Loopstick AM Radio Antenna
- Micro Power AM Broadcast Transmitter
- FM Beacon Transmitter (88-108 MHz)
- Op-Amp Basics - The text information for the basic Op-Amp operation, 2nd order filters and bandpass filters was obtained in part from the paper back book "Design of Active Filters, With Experiments" by Howard M. Berlin, 1977. The book is out of print but possibly can be found at used book stores, or through Amazon.com
- Active 2nd Order Filters
- Bandpass Filter (Single Op-Amp)
- Low Power Op-Amp - Audio Amp (Intercom)
- Crystal Radio Circuits
- Touch Activated Lamp
- Game Show Who's First Indicator Lights
- Salt Water Battery
- Transistor, Diode, IC outlines

Circuits Controlling Relays

- Push Button Relay Toggle Circuit With One Transistor
- CMOS Toggle Flip Flop Using Push Button (CD4013)
- CMOS Toggle Flip Flop Using Laser Pointer
- 555 Timer Monostable Circuit Using Pushbutton
- Generating a Delayed Pulse With a dual 555 Timer
- Light Activated Relay (toggled)
- Photo Electric Street Light
- Power-On Time Delay Relay Circuit
- Power-Off Time Delay Relay Circuit
- Electronic Thermostat Relay Circuit
- AC Line Current Detector
- Pinewood Derby Finish Line Lights
- Pinewood Derby Finish Line Using a Computer - Scores times and places.
- Controlling relays with logic voltages
- ....

- Simple Op-Amp Radio
- Low Frequency Sinewave Generator
- 3 Transistor Audio Amp (50 milliwatt)
- RC Notch Filter (Twin T)
- Analog Milliamp Meter Used as Voltmeter

Semiconductor Data Sheets

TI Semiconductors (search)   National Semiconductors (search)   Motorola NTE

Software (Moved to separate page)

Java Script Calculators

Resistor Color Code Calculator - Graphical resistor color code calculator by Danny Goodman. Uses pulldown menus and a realistic picture of a resistor.
Another Resistor Color Code Calculator - This one uses check boxes instead of pulldown menus and also calculates the equivalent value of two resistors in parallel. My own creation.
Ohm's Law Calculator - Java Script to solve Ohm's Law for Voltage, Current, Resistance and Power. Enter any two unknowns and solve for the other two.
Voltage Divider Calculator - Solves voltage, current, and power dissipation problems for two element resistive voltage dividers.
L or C Reactance Calculator - Java Script to calculate capacitive or inductive reactance and resonant frequency. For ideal devices only, resistance not included.
Allen Newman's Impedance Calculator - Solves passive series RLC networks, for reactance, impedance and phase angle.
RC Time Calculator - Java Script to solve R and C values for given values of time or instantaneous voltages.
RL Time Calculator - Java Script to solve R and L values for given values of time or instantaneous current.
555 Timer - Frequency and Time Interval Calculator - Calculates positive and negative time intervals for the 555 timer based on R and C values. Also contains descriptions and operation of each input and output of the timer and schematics for the two basic modes of operation (monostable

or "one-shot" and astable or "rectangular wave oscillator"). Also contains a pictorial diagram of the timer connected as a LED flasher and a table of connections for the 556 timer (dual 555 timer).
LED Series Resistor Calculator - Finds the series resistance needed for various series LED combinations and supply voltages.
The Electronics Calculator Website - Several calculators for Ohm's law, capacitor or inductor impedance, tuned circuits and RC time constants.
Several JavaScript Calculators by John Owen. - Audio op-amp filter, Op-amp circuit, Decibels, Zener Diodes and more...
Gregorian Calendar - Displays any month from Oct 1582 forward.

Links to Other Hobby Electronics Sites and Useful Information

Don Klipstein's LED Website - Lots of useful LED information, FAQs, and sources for the brightest and most efficient LEDs.
Circuit Archive - University of Washington Circuit Archive, lots of good circuits and links.
EDUCYPEDIA - The educational encyclopedia (Electronics section)
Tomi Engdahl's Electronic Info - Links to a wide variety of analog and digital circuits.
Imagineering On-Line Magazine ,The Design Corner, over 100 circuits in pdf format.
Tom Loredo's Electronics Bookmarks - Many resources for electronics hardware and software.
Harry's Homebrew Homepage - For building amateur radio equipment. Antennas, Receivers, Transmitters and other useful circuits.
Links for FM Transmitter Kits, Circuits, Electronics ...
Electronics Links and Resources -Links to circuits, components, educational sites and more..
Tony's Website - R/C Gadgets and electronic circuits for the hobbyist.
Steve Walz's FTP Site - FTP Resource Site, 1000 Files in 50 Directories.
Wenzel & Associates (Circuits) - Technical Library, Hobby Circuits.
Samuel M. Goldwasser Homepage - Silicon Sam's Technology Resource - FAQs, Links, Troubshooting & Repair, Laser info, Circuits.
Diana's Electronics info page
Beyond Logic - Information on the PC Parallel, Serial and USB ports.
How Stuff Works - Interesting site on how things work, but you will have to clear your screen of many pop up ads.
Deep Cycle Battery Frequently Asked Questions
Energizer Battery Data - Capacity, Weight, Size, etc.
www.saroff.com Has some useful search engines for locating parts and

data sheets.

Commercial Electronic Kits and Projects

- TheLEDLight.com Luxeon LEDs, LED bulbs, fixtures, flashlights, lanterns, clusters, arrays, and more...
- lsdiodes.com Basic collection of bright LEDs in several colors at low prices. Brightness ranges from 4000 mcd to 12,000 mcd for the white LEDs.
- JDR Microcontrollers Books, Kits, Test Equipment and more.
- Alltronics Electronic Kits

Electronics Educational Sites

- PIC Microcontroller Tutorial A very good introduction to PIC micros that includes 13 tutorial pages to get you started programming PICs. You will also need a programmer to load the finished program (.HEX file) into the PIC. The DOS programmer software and schematic for the programmer can be downloaded from David Tait's PIC archiveThe file you need is PIC84V05.ZIP. The file contains DOS software and programmer schematic that will work with the PIC16C84, PIC16F84 or the newer PIC16F628 which can be purchased on e-bay for about $2.68 or obtained from www.glitchbuster.com

- Lessons In Electric Circuits - A free series of textbooks on the subjects of electricity and electronics.
- Play Hookey Basic ideas about op-amps, analog circuits, optics, computers and digital logic.
- Alex's Electronic Resource Library An online guide to useful electrical and electronic information.
- Electronics Tutorials A good comprehensive site with detailed examples and book recommendations.
- Basic Electronics Tutorial (Iguana Labs)
- The Art of Electronics (Purchase the book) 1125 large format pages, 80 component-selection tables,1500 figures, extensive practical advice, back-of-the-envelope techniques, exhaustive 4000-entry index.

- KitZ Electronic Kits
- Electronics USA - LED Digital and Binary Clocks, LED Timers (Up and down counting), LED flashlights, and a few other items, as kits or assembled.
- Centerpointe Electronics Store
- Hobbytron - The largest selection of fun electronics and toys!
- Almost All Digital Electronic Kits
- DTE Microsystems
- Hallbar Electronic Kits and Projects
- Kits-R-Us Electronic Kits
- Microchip Technology Inc. (PIC) Controllers
- Circuits For Sale -Subscribe and receive schematics for 1000 circuits, plus FREE software - SuperCAD Lite, SuperPCB Lite, to draw circuit diagrams and build printed circuit boards.
- Mental Automation's products ECAD tools: schematic capture, printed circuit board design/layout, autorouting, circuit simulation, SPICE, and CD ROM Encyclopedia of Electronic Circuits, all running under Windows.
- Express Printed Circuit Boards Download PCB software to layout your project, E-mail the resulting file and receive delivery of finished circuit boards via Federal Express in 3 working days.
- PCB Express 1-Day Delivery, Economical, Easy to order and track, Lot charge as low as $80, E-Mail Help
- Used Electronic Equipment For Sale at E-Bay Online auction community, buy, sell, trade.
- C. Crane Company LED Flashlights, windup radios, and other specialty items.
- Cyber Circuits Software and Demos
- CircuitMaker Student Version (3.4M) Get ahead in class with the FREE CircuitMaker Student Version. You will be able to build and simulate circuits in a fraction of the time it takes in the lab.
- DC Circuits Department of Physics, University of Guelph.
- Elements of AC Electricity
- John Adams Beginners Electronics
- Electronics For Beginners

Newsgroups

- sci.electronics.basics
- sci.electronics.components
- sci.electronics.design
- sci.electronics.repair
- sci.electronics.misc
- sci.electronics.cad
- sci.electronics.components
- sci.electronics.equipment
- alt.engineering.electrical
- Search Newsgroup Discussions

Electronic Component Suppliers

- Mouser Electronics
- DIGI-KEY Corporation
- Allied Electronics
- Surplus Traders (Solar panels)
- Jameco
- Hosfelt Electronics
- Radio Shack
- Electronix Express - Components and test equipment for schools, colleges and industry. Very nice site.

• SpamCop - Locate the source of unsolicitated mail (Spam) and file a report with the postmaster or abuse department of the originating site. All spam received at my e-mail address will be forwarded to the abuse department of this web page host. •	• Dan's Small Parts and Kits -Good selection of small components at low cost. • Bill's Surplus Parts For Sale- Resistors, capacitors, semiconductors and a few other items. I don't have a large inventory, just more than I need.

Go to top

Having trouble building a circuit similar to something on this site?

Try posting a message with circuit details to one of the electronic newsgroups, either sci.electronics.basics or sci.electronics.design Many readers of those groups will offer ideas and a few specifics at no charge. If you need more detailed help and follow up advice, maybe I can help.

Send a detailed description of your circuit and objective. If it is within my expertise and relates to the projects on this site, I will work with you via email to help solve the problem. I can also test and refine the circuit on a vector board for a nominal fee.

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Beginner Tutorials

Microcontroller Beginner Kit Instructions (includes all tutorials with a *)
*Basic Concepts
*Basic Components (Resistors, Diodes, LEDs, Switches)
*Finding the value of a resistor by reading it's color codes
*Using a Breadboard (Socket Board)
*Using Ohm's Law
*Learning to use LEDs and Transistors
*Pulses, Oscillators, Clocks...
*Building a 5 Volt Power Supply
Using a Multimeter - Some Simple Pointers
-5 Volt DC & -10 Volt DC Power Supply

IntermediateTutorials

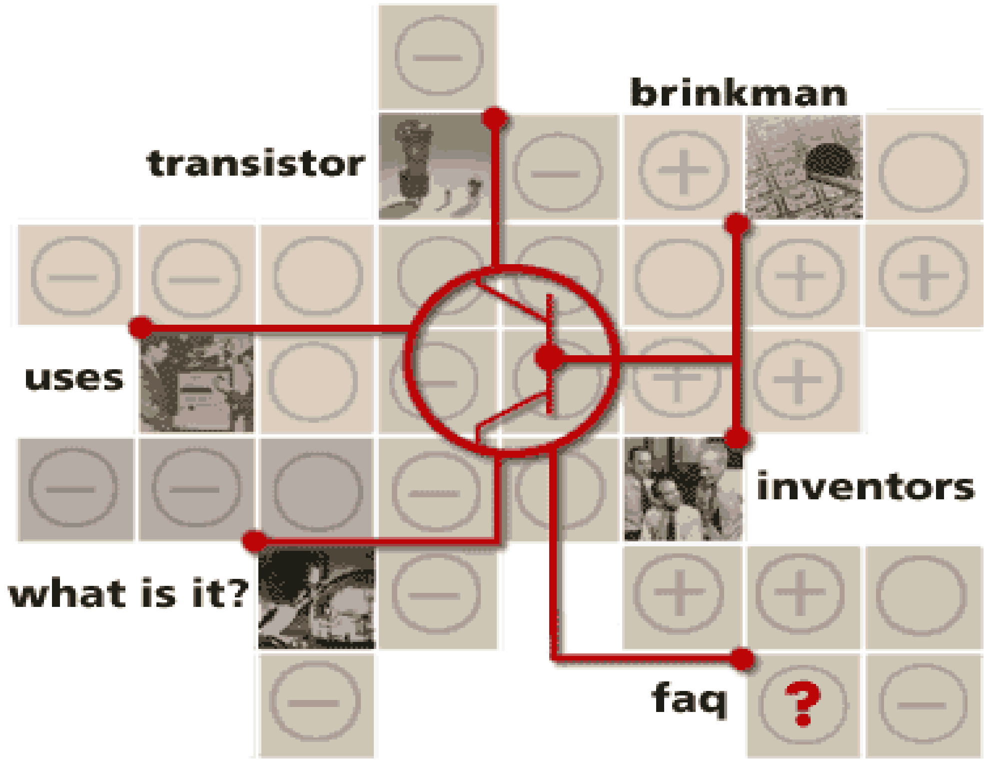
Truth Tables
First Microcontroller Project - 8051
C Programmers Guide to Building Hardware - Part 1
*First Microcontroller Project - 2051
*Second MC Project - 2051 as 8 bit Counter
*Making Sound With The 2051 Microcontroller
*Using a 7 Segment LED Display with a 2051
*Using Switches as Inputs

Advanced Tutorials

Digital Clock Using Four 7-Segment Displays
Using 8051 RAM (The Game of Simon)
Non Volatile RAM Memory - EEPROM
Light Sensor Project
Temperature Sensor Project
Using the LCD Module
Pulse Width Modulation
LCD Instruction Set
Data Collection - Analog to Digital Conversion and Communicating with a PC through the Serial Port
MIDI Controller

This page last updated on June 25, 2004.

The Transistor



The transistor legacy: then and now.
Bell Labs is the birthplace of the transistor, inventing the device that led to a communications revolution.

This web presentation, celebrating more than 50 years of the transistor, is also available in PDF format. Download the PDF now (446 KB).

Tomi Engdahl's Electronics Pages

Tomi Engdahl's Electronics Pages is going on major restructring.

Electronics links have been moved to www.epanorama.net

The electronics link section with thousands of links has changed it's name to ePanorama.net. The new pages can be now accessed at easy to remeber address www.epanorama.net. Click the address to go to the main site for ever growing electronics link collection.

New pages have a new colors and look, but still the main structure of the pages are same. The new pages has has a SEARCH ENGINE and other nice features like electronics acronyms search.

Useful electronics information collections by Tomi Engdahl in this server

- Electronics circuits designed by Tomi Engdahl
- Electronics document archive
- Electronics documents written by Tomi Engdahl
- Ground loop resources page
- Joystick port information and circuits
- PC hardware pages
- sfnet.harrastus.audio+video FAQ
- sfnet.harrastus.elektroniikka FAQ
- VGA to TV conversion information and circuit
- VGA to workstation monitor FAQ

This site is made to be best Viewable With Any Browser. This web site has very few graphics because Internet is slow for most users. This site is intentionally text based to facilitate ease of use for all visitors and to provide the fastest possible access.

Site info

Home site: http://www.hut.fi/Misc/Electronics/

This main site is located at Helsinki University of Technology main web server www.hut.fi which has a fast connection to Internet through FUNET ATM backbone network. The computing centre has given me enough free disk space for this web project. Helsinki University of Technology is located at Espoo Finland.

This electronics information web page collection is designed and maintained entirely by Tomi Engdahl.

I feel that Internet is about information and I care more for the content of my pages than for the appearance.

Tomi Engdahl <tomi.engdahl@hut.fi>

Access Excellence @the national health museum

the Site for Health & Bioscience Teachers and Learners

What's News | Resource Center | Health Headquarters | Activities Exchange | Let's Collaborate | Biology Ed Online

Sleep Disorders and Biological Rhythms. *New* from the National Institutes of Health, this interactive module explorse the scientific process of sleep, the importance of good sleep hygiene, and the negative consequences of sleep deprivation. ... (more)

Vaccines -- How and Why? " ... long before the processes of recovery were understood, an interesting thing was observed: if people recovered from a disease, rather than succumbing to it, they appeared to be , ... "(more)

Ancestral Hemoglobin. "A primitive form of hemoglobin has been found in single-cell microbes living in extreme environments, and ... " (more)

DNA Primer: An Introduction to DNA and Disease Detection. Advances in technology in the last 30 years have driven changes and advancements in ..." (more)

Sneeze. You're sitting in class, and Piper, one of your friends, starts sneezing like a madman! What happened to Piper? -- can you help?

Sports Injuries. The Olympics are here! "As the summer Olympics get underway, many of us will be inspired to run, jump, bike and swim just like ..." (more)

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Ecology of the Dump

Judith Brown and Randyll Warehime
1991 Woodrow Wilson Biology Institute

Introduction:

Waste management is becoming a serious problem for land-scarce communities. It is essential that students understand that what we bury does not all disappear and that there is a real need for recycling. The following are three activities concerning solid waste management. You may choose between a short-term activity (one week) or a long-term activity (several months). The follow-up activity is suitable for both.

Resources:

Rathje, William L., Once and future landfills, **National Geographic**, Volume 175, No. 5 (May 1991), pp 116-134.

Short Term Activity:
A Dump in a Petri Dish

Objectives:

At the end of this activity students should:

- Determine which types of garbage are biodegradable and which are nonbiodegradable.

Background:

The disposal of solid waste materials has become a serous problem for many communities. A common means of disposing garbage is to layer it with dirt in a landfill. Landfills are reaching capacity levels or are already filled in many parts of the country. Because we have a mounting volume of garbage being produced, new methods of disposal are needed. When developing these new methods, scientists must take into account both the effect on the environment and the cost of technology.

Materials per lab group:

4 Petri dishes, wax pencil, tape, garden soil, dropper, water, samples of garbage which could include paper, vegetable or fruit pieces, meat, bones and Styrofoam.

Procedure:

1. Label the bottom of 4 Petri dishes from #1 to 4. Write your name and the date on each dish. Section the bottom of the dish into 3 sections using a wax pencil.
2. Gather 12 small samples of garbage. Cut the samples into 2 centimeter squares.
3. Put three samples in each Petri dish - one in each section.
4. Record the nature of the sample materials in each dish. Indicate the size, color, texture, odor and any other features you think are important. Predict how each of the samples will look after one week.
5. Cover the sample materials with garden soil. Use a dropper to add enough water to make the soil moist but not soggy.
6. Tape the lid onto each dish and keep at room temperature.
7. After one week, examine the dishes and record any changes in the color, odor, texture, size of the samples.

Extensions:

1. Some landfills are sealed causing them to become an anaerobic environment. In order to simulate these conditions and demonstrate the effect of anaerobic environment on degradation rates, the following activity could be tried.

   An anaerobic environment can be devised by putting the Petri dishes with the garbage samples inside a bell jar with a burning votive candle inside. Place a set of the Petri dishes containing the garbage samples and soil inside the bell jar. Tape the jar closed. Leave for a week. Compare the amount of degradation in an aerobic environment to the anaerobic environment.
2. For one full day, collect the garbage and trash from your house. Divide this into five plastic bags. Bag 1 - glass jars and bottles, Bag 2 - aluminum cans, Bag 3 - plastic containers, Bag 4 - paper goods, Bag 5 - wet garbage. Use a bathroom scale to find the mass of each bag. Using this data, predict the quantity of garbage your family will produce in one week, one month and one year.

Long-Term Activity:
Rubbish In, Rubbish Out?

Objectives:

At the end of this activity students should:

- Have further practiced measuring skills, hypothesizing, taking data, and writing a lab report.
- Have worked cooperatively to test a hypothesis.
- Have observed the relative biodegradability of metal, plastic, and paper products.

Background:

I use this as a beginning-of-the-year and end-of-the-year activity . While observing different materials' relative biodegradability and practicing measurement skills, hypothesizing, taking data, and writing a laboratory report, students cooperate to share data but are individually accountable for their lab report, which is the major focus of this exercise. Because the decomposition takes several months, I have students turn in a preliminary lab report at the end of a beginning-of-the-year unit on scientific method and then turn in a final report towards the end of the year. The preliminary lab report is a draft, so that the end-of-year lab report is a final, revised product of which they can be proud .

While most substances decompose slightly, all paper products rapidly decompose. Regular paper is completely gone when I dig up the packages four months later.

Materials:

Plastic screening (2 pieces/student), string, some type of non-biodegradable label (Styrofoam, dymo label tape), balance, rubbish (supplied by students).

Procedure:

1. Discuss the process of biodegradation and which materials might be biodegradable and which might not.
2. In groups, determine what materials to test for biodegradability. I suggest that one person in the group choose a type of plastic, another a paper product, another a metal, etc., to get a variety of materials that can be compared. Then hypothesize about what you expect to happen and why. A prediction of the percent you expect to decompose

and a deduction would be appropriate.

3. Each group member brings 10 pieces of the selected rubbish from home or the campus.
4. Weigh 5 pieces of your type of rubbish (e.g., 5 similar-sized pieces of aluminum can). Although each piece could be weighed individually and an average calculated, since some materials will readily decompose it is better to just weigh all five pieces together for a total weight. This is the control group. Similarly, weigh the experimental group.
5. Wrap your control and experimental groups of rubbish each in a different piece of plastic screen, tie them with string, and attach a label (one that doesn't decompose, e.g., Styrofoam or metal). Screen allows water and insects to do their work but keeps the rubbish together so that it can be retrieved.
6. Share data with your group so that you can compare a variety of materials. Turn in a preliminary lab report.
7. The experimental rubbish packets are buried for several months about six inches deep. Make sure you mark the burial site. The control packets are kept in the room.
8. Rubbish packets are dug up. Weigh the contents of both packets then share your results with your group (which is like a reunion, since groups have been changed several times during the year). Then turn in a final lab report.

Extensions:

Posters, letters to the editor can be made urging the use of biodegradable products, particularly in packaging.

Follow-Up Activity:
Where did all the paper go?

Objectives:

At the end of this activity students should:

- Understand that there is a natural enzyme system in the soil which is capable of biodegrading some of the wastes of today's society.

Background:

Students are often surprised to find that the paper in their garbage samples from the above labs has disappeared. There is a cellulose degrading bacteria present in the soil which is responsible for this. A simpler model which demonstrates this process is to isolate starch degrading bacteria from the soil using starch agar plates.

Materials:

Soil, sterile distilled water, soluble starch, nutrient agar, 20 Petri dishes, spreading loop, Bunsen burner, gram iodine

Preparation:

To make starch agar:

- Add 2.0 g of soluble starch to 400 ml of distilled water.
- Add 9.2 g. of nutrient agar and autoclave 15 minutes at 120oC. This will make 20 plates.

To make Gram's Iodine:

- Add 1.0 ml of iodine and 2.0 g of Kl to 100 ml of distilled water.
- OR use Lugol's iodine, 3.0 ml in 100 ml of distilled water.

Procedure:

1. Weigh out 1 gram of soil and add this to 99 ml of sterile distilled water. Dilute this further by removing 1 ml of this mixture and adding it to another bottle which contains 9ml of sterile distilled water. Mix by swirling.
2. Remove 0.1 ml of this mixture and put on a Petri dish containing starch and agar. Spread this mixture evenly around the plate using the sterile spreading loops.
3. Turn the plates over and leave overnight.
4. The next day, examine the plate to see if clear areas are developing in the starch agar. If clear areas are seen, flood the plate with the iodine mixture. Pour off the excess iodine after 1 minute. The starch will stain blue. The starch digesting bacterial colonies will have a brown halo around them where the starch has been consumed by the bacteria.
5. Leave the plates another 24 hours and restain. The cleared areas will have increased dramatically.

Student Analysis:

1. Draw the pattern of colonies on your plate.
2. What does each colony represent?
3. What is the clear area on the plate?
4. Explain why the plates containing starch are effective in isolating starch-degrading

bacteria.

5. What enzyme do starch-degrading bacteria degrade?
6. How could this method be used to isolate oil-degrading bacteria?
7. Summarize this lab experience and include possible applications of this procedure to help clean up the environment.

Safety:

Wear goggles while working with iodine.

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Waste Management

Frances Vandervoort, Philip Nelson, and Carolyn Hayes
1991 Woodrow Wilson Biology Institute

Objectives

The purpose of this unit is to make students aware of the amount of trash they generate, the problems that result, and possible solutions. Students will investigate household trash, biodegradability, packaging, and recycling. After completing these activities, many students will show interest in these and other local environmental issues. This interest often translates into the type of involvement needed to solve modern problems.

Background

These activities can be used to introduce the study of land use and resource management. They are an appropriate prologue to developing an understanding of issues involving energy and ecological management.

Activity 1. Analysis of Household Trash

Materials

- Household trash
- Rubber aprons
- Old clothes (long pants)
- Gloves

- Safety goggles
- Large sealable plastic bags
- Plastic garbage bags
- Tongs (crucible, if possible)
- Bathroom scale
- Disposable breathing mask

Procedure

1. Assign ten or more students to collect and separate the trash generated by their families over the period of two days. Specify that they include only household refuse. Yard, construction, or chemical wastes are not permitted for safety reasons. Separate bags will be required for plastics, metals, glass, food waste, and miscellaneous. Food waste should placed in large sealable plastic bags. All other materials should be kept in tied trash bags. Precautions must be taken to avoid spillage during transport and handling.
2. On the day of the lab, collections should be delivered to a common site. The best site would be a paved area next to a large school refuse bin.
3. Students should record the mass of each bag. Find the total mass in each category, and the average mass produced per person in each category. After this, dispose of the food waste bags and the miscellaneous bags without opening them. They may represent a health hazard.
4. Open the remaining bags and subdivide their contents. Separate piles of paper can include craft, colored, newsprint, glossy, miscellaneous, and stationery. A separate pile should contain cardboard. Similar divisions can be made to separate different types of metals, plastics (look at the recycling number at the bottom of plastic containers), and colors of glass. Record the mass of each pile. Calculate the mass generated by each person and use this to estimate the total amount of each substance thrown away in your community. After classification, recycle materials that can be recycled and dispose of the rest.

   Note: Activities listed to this point are suitable for all levels of students. The following activities are suitable for higher achieving students.
5. Divide the class into research groups. Each group will be responsible for gathering information and articles from periodicals relating to one or more of the refuse categories. Topics for articles should include possibilities and problems involving reuse, recycling, composting, incineration, landfill, or other solutions pertaining to a particular type of refuse. Primary concerns of cost, safety, environmental impact, and energy requirements should be kept in mind. The Readers' Guide to Periodic Literature may be one of the best sources of current information for general readers.
6. Each group should make a recommendation for dealing with their category of refuse. This should be based on their own research.
7. The entire group can formulate a plan for dealing with their community's household

trash. Plans should include means of paying for the plan. It should also address whether the material should be sorted. In other words, should it be sorted by the persons generating it, or should be sorted in a central collection facility?

8. Have each student submit a report about the activity for evaluation by class and teacher. Additional activities may include assigning students to examine disposal problems not addressed by the group. This may include chemical waste, nuclear waste, tires, medical waste. In other words, should it be sorted by the persons generating it, or should be sorted in a central collection facility?
9. Have each student submit a report about the activity for evaluation by class and teacher. Additional activities may include assigning students to examine disposal problems not addressed by the group. This may include chemical waste, nuclear waste, tires, medical waste, yard waste, motor oil, batteries, etc.
10. Students may choose to present the results of these studies to local governmental officials and media.

Activity 2. What is Biodegradability?

1. Ask students to bring about 4 cups (approximately one liter) of garden or other soil from an outdoor area. Ask them to bring objects and materials from home that they consider biodegradable or non-biodegradable. Substances may be small pieces of fruit, bread, meat, plastic, paper or cardboard, charcoal, etc.. etc. The soil is then placed in a metal tray or bread pan. The soil should be at least 7 cm deep (2 1/2 inches). Divide the pan into 6 areas, and bury a small piece (about 1 cc) of material in each area. Place a plant label or ice cream stick in each area, telling what material is buried there.

   Every other day for two weeks, dig up the substance and describe its appearance, smell, etc. How has it changed? Why? What materials show little or no change? Why not?

   (Note: This is a modification of a BSCS Green Version experiment used successfully for many years in high school classrooms.
2. Ask students to conduct a survey of their neighborhood supermarkets. Find out if the markets provide information about packaging, biodegradability, and toxicity.
3. Ask students to learn about local landfill and waste treatment practices. This can be done by library research, interviewing government officials, and obtaining information from community action groups and service organizations.
4. Ask students to interview people who work in various waste management fields. This can include employees of solid waste management companies, sanitary engineers, landfill operators, or managers of recycling companies. Local, state and federal regulatory agency employees, and elected government official could also be interviewed.

Activity 3 - Pick The Best Package

Objectives:

1. Students will be able to distinguish between different types of packaging.
2. Students will be able to determine whether packaging can be recycled or not.

Student Handout

Give the students a copy of this survey sheet at the beginning of class and after 10-15 minutes begin discussing their choices using the answer key given.

When you go shopping, if all other considerations are equal, pick a product wrapped in the least amount of packaging. Given the following list try and classify them according to the ratings listed.

- a check ( ) means the item can be reused or recycled
- a zero (0) means it can be incinerated or landfilled
- a minus (-) means it cannot be disposed of easily and should be avoided if at all possible.

Kind of Package	Grocery Store Item	Rating
No packaging or natural package	Melons, pineapples, fruits	
Returnable glass bottles	Milk bottles, soda and beer bottles with deposit returns	
Reusable Containers	Cookie and cracker tins, heavy-duty plastic plates on which some microwave dinners are packaged	
Uncoated paper	Bags of candy, cookies, chips, and other snacks	
Uncoated cardboard	Cereal boxes, detergent boxes, dessert mix boxes	
All-steel cans	Many canned fruits and "veggies"	
All-aluminum cans	Beverage containers	
Steel cans with aluminum tops	Pull-top cans	
Glass bottles with twist-off tops	Soft drinks	
Wax paper	Liners in cake boxes	
Cellophane, plastics	Windows in paper boxes and plastic bags	

Coated paper	Paper milk and juice cartons	
PVC	Clear plastic bottles and plastic wrap	
Aluminum-foil-based containers	Foil-lined boxes and bags	
Collapsible metal tubes	Toothpaste, hand cream	
Metal and plastic pumps	Toothpaste pumps	
Aerosol cans	Toiletries, deodorants, hairsprays, insecticides	

Answers for the Teacher:

Kind of Package	Rating
No packaging	check +
Returnable glass bottles	check
Reusable containers	check
Uncoated paper	0
Uncoated cardboard	0
All-steel cans	0
All-aluminum cans	check
Steel cans with aluminum tops	0
Glass bottles with twist-off tops	check
Wax paper	0
Cellophane, plastics	0
Coated paper	0
PVC	-
Aluminum-foil-based containers	-
Collapsible metal tubes	-
Metal and plastic pumps	-
Aerosol cans	-

Reference:

Save Our Planet - Diane MacEachern; Dell Publishing 1990.

Activity 4 - Reduce, Reuse, Recycle

Materials:

Have students bring in examples of various packages that were presented in the "Pick the Best Package" activity.

Suggestions:

1. soda containers - aluminum, plastic, returnable
2. shampoo bottles - plastic (no. 1,2, others), glass
3. potato chips - cardboard can, cellophane bag, foil bag
4. ketchup - glass, plastic
5. vegetables - fresh, frozen, canned
6. cookies - boxed, bagged, blister packed
7. juice - frozen concentrate, glass and plastic bottle
8. eggs - styrofoam or cardboard carton
9. hair spray - aerosol can, plastic pump can
10. laundry supplies - box, boxed concentrate, plastic
11. toys - cardboard, cellophane, blister packed
12. margarine - plastic tub or squeeze bottle, cardboard box with foil.

Procedure:

1. Rate each package on its ability to be recycled.
2. Identify which types of packages are being recycled in your community. Then describe the steps involved in recycling each type of package. (Note: This may require some outside research.)
3. Identify the best type of packaging for each product based on the recycling capabilities of your community.
4. Students should make suggestions on how to reduce the use of non-recyclable products in your community

References

Cohen, Levin et al. **Coming Full Circle: Successful Recycling Today.** New York: Environmental Defense Fund, 1988.

Keep America Beautiful, Inc. **Overview: Solid Waste Disposal Alternatives. An Integrated Approach for American Communities.** Stamford, CT. 1989.

O'Leary, Philip R. "Managing Solid Waste." **Scientific American.** December, 1988.

Schwartz, Anne. "Drowning in Trash, We Begin to Discard Our Wasteful Ways." **Audubon Activist,** May- June, 1988.

Waste Management "Grabbers"

"Grabbers", used to generate interest in solid waste management, could include the following:

1. Arouse students' interest in this issue by asking them such questions as: (1) How many automobiles are junked in the United States eash year? (Ans. 7 million), and (2) Which NFL stadium is built on garbage (sanitary landfill). (Ans. Mile High Stadium in Denver, Colorado).
2. Give students a medium-sized plastic bag. Ask them to attach it to their belt or bookbag, and put into it every bit of waste they generate (except food waste) for a 24 hour period. At the end of that period, weigh and examine it. Does it come from overpackaging? Is there anything that the student didn't really need? What is the difference between needs and wants?
3. Give the students information about amounts, including volume and mass, of garbage generated by the average American each day. Use this amount to show how much land is needed to hold that amount, and then consider the environmental consequences of the large volume of waste generated in the United States.

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Activities Exchange Index

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Hazardous Wastes Disposal Theme Page

This "Theme Page" has links to two types of resources related to the study of Disposal of Hazardous Wastes. Students and teachers will find curricular resources (information, content...) to help them learn about this topic. In addition, there are also links to instructional materials which will help teachers provide instruction in this theme. Please read our disclaimer.

- Basel Action Network (BAN)

  BAN is "an international network of activists seeking to put an end to the export and dumping of hazardous wastes from rich industrialized countries to poorer, less-industrialized countries." Their site contains information about the Basel Convention (an international treaty to end the most abusive forms of hazardous wastes trade), background information, status of what countries have signed the agreement, a library of letters and briefing papers, and a set of related links.

- Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal

  The Basel Convention is the response of the international community to the problems caused by the annual world-wide production of tonnes of wastes. This global environmental treaty regulates the transboundary movements of such wastes and obliges parties to the convention to manage and dispose of the wastes in an environmentally sound manner. This link is to the United Nations Secretariat which manages the convention.

- [The] Biology Project: Chemicals and Human Health

  Tutorials and online problem sets designed for high school and university students from the University of Arizona. Content coverage includes: the effect of metals on the kidneys and on kidney cells, fundamental principles of toxicology, lung toxicology, and environmental tobacco smoke and lung development .

- Disposal of Household Hazardous Materials

  A fact sheet outlining three steps that should be followed before disposing of household hazardous materials.

- Energy Wise Options for State and Local Governments

  Chapter 3 in this online book addresses Waste Reduction.

- Garbage: How Can My Community Reduce Waste: Hazardous Waste

  Sections on definitions, who's responsible, a knowledge test, and solutions to the issue are presented by The Annenberg/CPB Project.

- [The] Global Waste Trade

  Links to documents on the trade in hazardous wastes organized by continent/country.

- ## [Hazardous Waste: Alternatives]

  A list of non-toxic or less-toxic products that can be used as alternatives to hazardous household chemicals.

- ## [Hazardous Waste Cleanup Information]

  This site contains information about innovative treatment technology as well as programs, organizations, publications and other tools.

- ## [Hazardous Waste Trade]

  A paper from the International Institute for Sustainable Development describing the trade in hazardous wastes and the associated issues.

- ## [Reduce, Reuse, Recycle Theme Page]

  This CLN Theme Page will complement the research that students and teachers are conducting on hazardous waste. Lots of lessons and lesson plans.

- ## [ToxFAQs]

  These FAQs from the Agency for Toxic Substances and Disease Registry (ATSDR) are summaries about hazardous substances. They provide answers to questions about exposure to hazardous substances found around hazardous waste sites and the effects of exposure on human health. The FAQ sheets are organized alphabetically by chemical and a search engine is also available.

- ## [Toxicology: An Environmental Education Unit for Secondary Schools and Communities]

  From the Alberta Environmental Protection and the Canadian Network of Toxicology Centres, this seven lesson unit starts with an introduction to toxicology, moves on to toxicology topics of interest, and ends with a case study on toxic effects and water.

- ## **United States Environmental Protection Agency**

  This comprehensive site from the U.S. Environmental Protection Agency has resources targeted for both students and teachers.

  - [The] Consumer's Handbook for Reducing Solid Waste Practical steps that families can take to reduce the amount and toxicity of garbage.
  - HAZ-ED: Classroom Activities for Understanding Hazardous Waste Teacher resources include downloadable PDF files that offer warm up exercises, activities, fact flashes, and a glossary.
  - Municipal Solid Waste Factbook An electronic reference on household waste management practices. Lots of facts to pull out - note these data will be U.S. based.
  - Office of Solid Wastes Online activities for students.
  - Recycle City Students learn about the three R's by touring various sections of "Recycle City" and seeing how the various organizations and citizens reduce, reuse, and recyle. There's also a "Dumptown game" where students can play the role of a city manager who has been hired to start programs that encourage Dumptown's

citizens and businesses to recycle and reduce waste all the while remaining within a budget of course. An Activities section contains suggestions for using the site within the classroom.

- Waste No Words A crossword puzzle activity.

Top of Page

Note: The sites listed above will serve as a source of curricular content in Disposal of Hazardous Wastes. For other resources in Social Studies - Environment (e.g., curricular content, lesson plans, and theme pages), click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

There is no machinery at The Imagination Factory, and smokestacks don't pollute the air. Instead, we teach children and their caregivers creative ways to recycle by making art.

The Imagination Factory Departments and More

Education **Lessons/Activities** **Trash Matcher** **Badge Matcher** **Project Matcher** **Creative**

A Kid's Columbus	Previous Activities	Awards	Outlet Store	PR/Trashasaurus	Mail Art Show
	Links	Contact Us	Webmaster	Privacy Policy	

The Imagination Factory is located in Columbus, Indiana, an American city famous for its modern architecture and preserved older buildings. People come here from all over the world to see and study our architecture. Most of them are adults, but kids can find lots of buildings, sculpture, and other great things to see, too. Click A Kid's Columbus to take a virtual tour.

We are dedicated to making learning fun and preserving the precious gift of imagination. Please e-mail us at kidatart@kid-at-art.com with your comments and suggestions.

Sponsored, in part, by the Bartholomew County Solid Waste Management District.

The Imagination Factory graphic was created by Susan M. Brackney, author of The Lost Soul Companion, The Not-So-Lost-Soul Companion, and The Insatiable Gardener's Guide.

Lesson Plans

Lesson Plan # 1 Purpose: To show students what happens to the trash they throw away.

Lesson Plan # 2 Purpose: To show students the potential hazardous effects of common household products

Lesson Plan # 3 Pupose: To show students alternatives to household products that are not as hazardous to the environment.

Lesson Plan # 4 Purpose: To show students that reusing items decreases waste.

Lesson Plan # 5 Purpose: To show students how different types of paper will affect the quality of recycled paper.

Lesson Plan #6 Biodegradability Capsule (2nd & 3rd grades)

Lesson Plan #7 Fireplace Logs From Newspapers (1st - 6th)

Lesson Plan#8 Is Your School a Dumping Ground? (5th)

Lesson Plan#9 Junk Art (Kindergarten)

Lesson Plan#10 Making a Mini-Landfill (4th - 6th)

Lesson Plan#11 Paper Capers (4th - 6th)

Lesson #12 Best ever compost activity for (4th-6th). The objective is to learn about composting.

Lesson #13 How hot is my compost? For (7th-8th) The objective is to study the dynamics of heat in the composting process.

Lesson #14 Composting: a great, rotten idea (7th-8th). The objective is to have students investigate the pros and cons of composting.

Lesson #15 Where should it go? Recycle, Compost? Incinerater? Lansfill? (K-3rd) The objective of this lesson is to understand that solutions to garbage disposal problems are varied and complex.

Cornell's information on composting for teachers and students

More Composting Links for Teachers and Students

[Texas A&M Composting Facility] [Worm Composting] [Aggie Horticulture]

Recycle

by Charles Hoskowicz

Charles is a senior programmer/analyst for a San Diego-based computer software firm. He enjoys tennis, running, Tai Chi, bridge, chess, and movies.

Instructional Objective After playing the *Recycle* card game three or more times, players will be able to name all the recyclable items used in the *Recycle* card game.

Learners/Context The *Recycle* card game is designed for ages 8 - 12.

It would be used as part of a class on Ecology. The teacher or facilitator would introduce the idea of recycling, the value of such a practice, and how each and every individual needs to take responsibility for recycling all they can. After the introduction, the card game could be used to familiarize the students with the various items that are normally discarded in the garbage which, however, could be recycled. After playing the game several times, the teacher or facilitator would debrief the students to find out how many items they remember from the game. Incorporated into the debriefing stage, the teacher could talk about how each item is recycled and what effect not recycling that item has on the environment.

Rationale The card game is a fun way to familiarize young people with recyclable items. It heightens awareness by exposing the students to different recyclable materials. It also reinforces the concept of value in recycling by awarding points for accumulating a set of matching cards, and setting an arbitrary point total as the means for determining the winner. The hidden message here is that you are a winner if you recycle. Even for the non-winners there is the association of points for recycling as they get to claim their points at the end of each hand. (More about that in the rules.)

Rules The *Recycle* game is played like Fish. Fish is a game where players ask each other for cards that they need to make 2, 3, or 4 of a kind. If the other players do not have the card in question, the person has to go "Fish" for the card from the remaining undealt cards in the middle of the table. Once three or four of the same value cards are obtained, the cards can be claimed by laying them down face up on the table. The first person to get rid of all their cards wins that hand.

The difference in the *Recycle* game is that points are awarded for laying down 3 or 4 of the same recyclable. Score is kept and a winner is determined by being the first person to reach a certain number of points.

The Players The game can be played with two to four players.

The Dealer The first person to deal is determined by one person shuffling the deck and, starting with the person to the left, turning over one card or each person until a Mother Earth card is turned over. That is the first person to deal. The next person to deal will be the player to the left, and so on.

The Deal The dealer shuffles the cards and begins giving out one card at a time (face down) to each player until everyone has seven cards. The remaining cards are put in the center of table face down. This is where players will go to draw more cards if no one has the card asked for.

The Play Each player should arrange their hands by putting all the matching recyclables together. Play starts with the first person to the left of the dealer asking the other players: "Does anyone have any Newspapers (or any other recyclable) to recycle?" Any player having one or more of that card must give the card to the asker. (A player may NOT ask for a Mother Earth or a Toxic Waste card.) Each player who does not have the card asked for should respond: "No, check the garbage pile." When none of the other players have the requested card, the asker must go the remaining undealt cards to pick a card. Then the next person asks for a card, and so forth.

When a player gets 3 or 4 of one recyclable, they can lay them down only while it is their turn. A player's turn begins when the previous player is either forced to pick from the undealt cards or signals that they don't want to make a lay down. When only 3 of a kind are laid down by a player, anyone holding the fourth card of that kind may lay it down in front of themselves and claim points for it. See "The Score" below. The Mother Earth cards can be used as wild cards. Only one (1) Mother Earth card can be used with two (2) of a kind to make three (3) of a kind, or with three (3) of a kind to make four (4) of a kind. You cannot use two (2) Mother Earth cards with two (2) recyclables to make four of a kind. However, anyone having the matching recyclable card may exchange it for the Mother Earth card in the laydown.

Mother Earth cards can also be used to "neutralize" Toxic Waste cards. Toxic Waste cards are not desirable cards to have. The only way to get rid of a Toxic Waste card is by "neutralizing" it with one (1) Mother Earth card. The player must then pick two (2) cards from the pile to replace the two cards used in "neutralizing" the Toxic Waste. Again, however, any other player with a Toxic Waste card can exchange it for the Mother Earth card when it is their turn without having to pick another card from the pile.

Once a player has gone out, the other players can make laydowns of their own provided they have three (3) or four (4) of a kind. They can also make plays on the person who has gone out by playing a matching card on any of the first person to go out groupings. Mother Earth cards may only be used to complete a grouping, or neutralize a toxic waste card, by the person laying down a grouping. It may not be used to complete a grouping of someone else's laydown.

The Score Players **score** points for the following:

* 15 points for each three (3) of a kind

* 20 points for each four (4) of a kind

* 5 points for each single card played on an opponent's laydown.

Players **lose** points for the following:

* 5 points for each recyclable left in the hand.

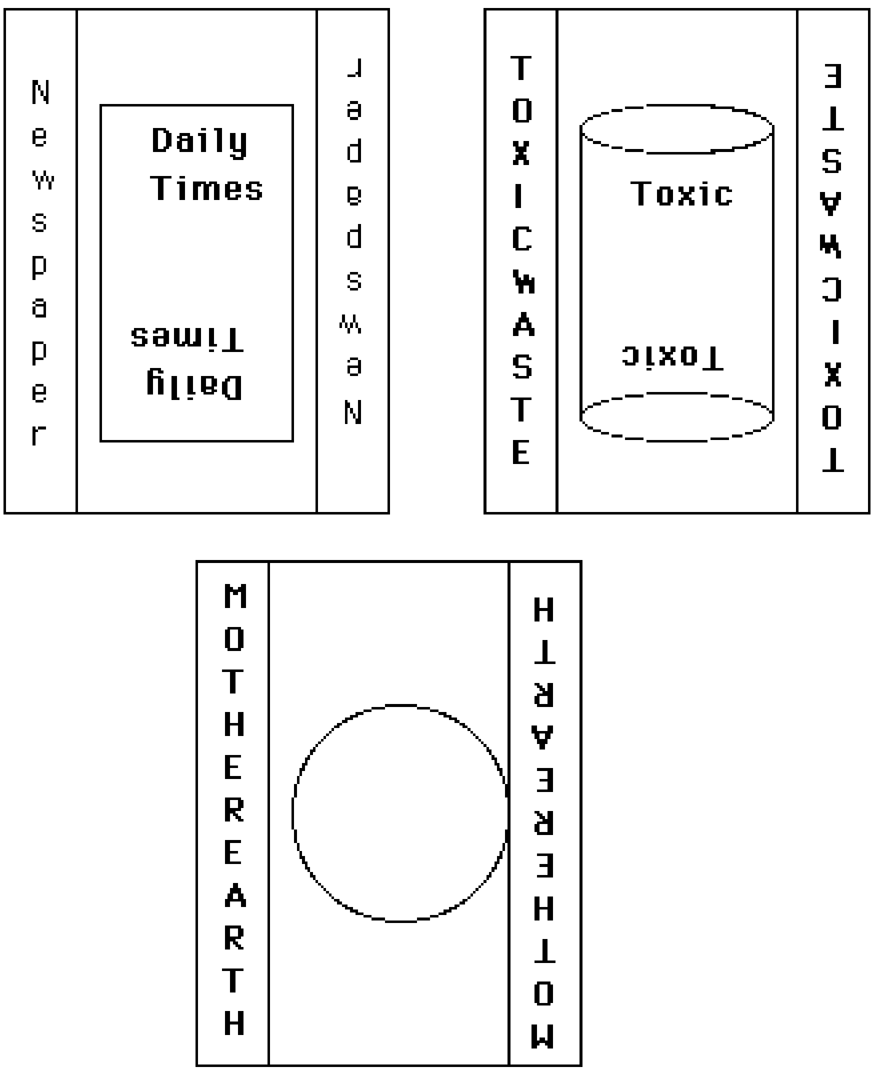
* 10 points for each Mother Earth card left in the hand.

* 25 points for each Toxic Waste card that has not been neutralized

* Players get 0 points for Toxic Waste laydowns.

The Winner The first person to reach 500 or more points is the winner. If more than one person reaches or goes over 500 points, the person with the most points wins.

Card Design



Deck Design The deck consists of 52 cards. There are four of each type of recyclables: Newspaper, Cans, Glass, Metal, Magazines, Plastic, Styrofoam, Junk Mail, Rubber, Computer Paper, and Used Car Oil for a total of 44 cards, plus four (4) Mother Earth and four (4) Toxic Waste cards.

Design Process First I thought about what the subject matter would be. After settling in on recycling, I began evaluating possible formats: rummy, solitaire, etc. I chose a rummy format because it seemed to me to be the best way get the message across: Collect, save, and reclaim recyclable materials.

The idea of the Toxic Waste card came a little later in the design processes. I was looking to bring in an avoidance factor into the game, something that would heighten interest. I struggled a bit on how a person would be able to get rid of the Toxic Waste card. I hit on the idea about a Mother Earth card that would serve as a neutralizer to the Toxic Waste card. Then the idea about using Mother Earth cards as a wild card seemed to fit right in. But there was still the problem of not giving people ample opportunity to neutralize the Toxic Waste card. That's when the idea came to allow anyone, when it was their turn, to exchange a matching recyclable for the Mother Earth card in anyone's played cards. This works because it adds some strategy to the game.

I 'm not sure that any ideas were actually thrown out, but rather it appeared to be a process of refining ideas that happened to come up. For example, the Toxic Waste card idea. I wanted to use the concept, but then I became concerned that the player could get one, or more, and not be able to get rid of them. So I thought about it. Getting three or four Toxic Waste cards might not give the players enough opportunity to discard them, especially since they could not ask for them. So when I came up with the Mother Earth card idea, it increased the likelihood of completing a grouping. But then I thought, what if the person only gets one Toxic Waste card? How can it be discarded? I came up with the idea of a one for one neutralizing scheme. This gave all players a chance to get rid of the Toxic Waste card and put a Mother Earth card out on the board where it could be traded for a Toxic Waste card. This seemed to be enough ways to get rid of the Toxic Waste card.

Site Navigation

Recycling Lesson Plans

Department of Environmental Protection

The following lesson plans were prepared Carl Hursh by the Bureau of Land Recycling and Waste Management to illustrate a variety of recycling concepts for grades Kindergarten through 12. Each lesson plan is marked for its intended grade level.

Site Navigation

LESSON PLAN:

Reduce, Reuse, Recycle

by Marva M. Ledwith
Wheatley High School
Houston, Texas

Objectives

- To define reduce, reuse, recycle
- To list materials that can be reduced, reused, recycled
- To become aware of how reducing, reusing and recycling effects our environment
- To list ways to reduce, reuse, recycle
- To make a personal plan of action to reduce, reuse, recycle **Internet Resources**

Examples of How to Reduce, Reuse, Recycle A Household Recycling and Action Guide. This is a guide of ways to reduce, reuse, recycle in plan no-nonsense terms.

How the 3 R's (Reduce, Reuse, Recycle) Can Effect our Environment Project 2050 - Save Earth. Gives an idea of how life would be with everyone involved in the 3R's and other environmentally sound activities.

Text Resources
Bernstein, Leonard and others (1996). Environmental science. Ecology and human impact. Menlo Park: Addison-Wesley Publishing Company.

Definitions

- **reduce - to use less**
- **reuse - to put again into service without changing**
- **recycle - to put again into service with changing**

Materials to Reduce, Reuse, Recycle

Student Activity:

Have the students list as many materials as they know of that are either reduced, reused and/or recycled. This can be a group activity. Encourage all ideas and discuss the ones that may be a little "too" original.

Lecture Notes:

There are several materials that are now being recycled. Paper is one of the easiest but each time it is recycled, the cellulose fibers in the paper shorten and weaken, reducing the quality of the paper. Some minerals can be recycled such as glass and aluminum. Junked cars are recycled. Many other metals are also recycled such as silver from photographic film and x-rays, copper from car radiators and telephone and utility cables, lead from car batteries, and zinc from plumbing materials. Other materials being recycled are motor oil and plastic.

How the 3 R's Effect Our Environment

Student Activity:

Have the students brainstorm how they think all our recycling and other efforts impact our environment. Do they think it is a waste of time? It is worth it? Does it really save our planet? etc.....

Lecture Notes:

When aluminum is recycled instead of refining 'new' aluminum, water and air pollution is decreased as well as consumption of energy. The recycling of motor oil keeps several toxic substances such as lead, cadmium, arsenic and benzene from polluting our land and air, not to mention the consumption of energy that is reduced in this process to clean as opposed to refining. The 3 R's reduce the amount of waste produced and the resulting disposal problems. They are also less polluting, cheaper and more energy-efficient than taking new material from the environment.

Ways to Reduce, Reuse, Recycle

Student Activity:

Have the students brainstorm on how they can reduce, reuse, recycle. Make sure they are very specific in how they would accomplish their desired activity to save the environment. Have them include individual as well as community activities.

Lecture Notes:

There are several ways of imposing the 3 R's. One is certainly to buy products made from recycled materials which completes the recycling circle. Another way which is most popular is to recycle/reuse paper, plastic, glass and other items through curbside recycling pickup or centers designated for that purpose. Repair items like appliances so that the garbage in landfills will be reduced.

A Personal Plan of Action

Student Activity:

Have students copy the following table and complete. This should be started in class but completed at home so students may involve other family members.

Activity	1	2	3	4
Description				
Target Date				
Impact				

These materials created by Marva M. Ledwith.
Last updated 2/24/96.

url = http://www.rice.edu/armadillo/Projects/Star/Facilitators/MLedwith/environ.html

My Personal Plan of Action- 3 R's

Solid Waste and Recycling

by Bernita Robinson

Lesson I - Litter Activity:

Introduction: Litter, especially paper, is our greatest source of waste.

Objectives: Students will:
-discover how much waste is generated in class
-offer some solutions to cutting down on waste in class

Time Allotment: several days to a week

Materials: Litter activity sheet, large bins to collect litter

Advanced Preparation: None

Procedure:
Prior to lesson the students will apply the KW (prior knowledge and what they want to know) of the KWL method.
-Introduce the lesson
-Class will do hands-on activity and discuss results connecting lesson to everyday examples.

Summary:
Have the students apply the L (what they have learned) of the KWL method.

Safety: No hazards.

Clean-Up: Recycle as much as possible

Home Activity:
Have students discuss the lesson with someone at home.

Lesson Assessment:
Based on participation in activity and what they have learned (L).

Additional Activities:
Students will create sculptures, jewelry and collages (sort and disinfect litter first). All art projects in solid waste and recycling lessons will be presented in a school wide art exhibit.

Lesson II - Paper Recycling Activity

Introduction: Paper is our greatest source of waste. We can cut down on paper waste by recycling our paper waste.

Objectives: Students will:
-Learn how to recycle newspaper waste

Time Allotment: 2 days

Materials: old newspaper, starch, beater or blender, large bowl, screen to hold paper fiber, sheet of plastic, block of wood, paper recycling activity sheet

Advanced Preparation:
-Collect old newspaper

Procedure:
-Prior to lesson the students will apply the KW (prior knowledge and what they want to learn) of the KWL method.
-Introduce the lesson.
-Class will do hands-on activity and discuss results connecting lesson to everyday examples.

Summary:
Have the students apply the L (what they learned) of the KWL method.

Safety: Make sure the students' clothes are covered with plastic or aprons.

Clean-Up: None.

Home Activity:
Have students discuss the lesson with someone at home.

Lesson Assessment:
Based on participation in activity and what they have learned (L).

Additional Activities:
Students may want to include leaves or other flat objects on their paper fibers.

Lesson III - Main Kinds of Solid Waste

Introduction:
Solid waste is a very serious problem. Americans throw away valuable waste products which can be recycled and used again. There are other kinds of solid wastes which help to destroy our environment.

Objectives: Students will:
-discover some of the main kinds of solid waste
-offer solutions to some of the solid waste problems

Time Allotment: 40 minutes

Materials: Main kinds of solid waste, activity sheet, pencil

Advanced Preparation: None

Procedure:
Prior to lesson the students will apply the KW (prior knowledge and what they want to know) of the KWL method.
-Introduce the lesson
-Class will do hands-on activity and discuss results connecting lesson to everyday examples.

Summary:
Have the students apply the L (what they have learned) of the KWL method.

Safety: No hazards.

Clean-Up: None.

Home Activity: Have students discuss the lesson with someone at home.

Lesson Assessment:
Based on completion of activity and what they have learned (L).

Additional Activities:
Students may wish to recycle cans, plastics and glass.

Lesson IV - Canned Pencils

Objective: Students will :
-recycle cans using various "waste" materials

Time Allotment: 30 minutes

Materials:
-old cans with clean edges, fabric scraps, old magazine pictures, glue, scissors, string and ruler for measuring distance around can and length of can, canned pencil direction sheet.

Advanced Preparation:
Have students bring in materials prior to activity.

Procedure:
Prior to lesson the students will apply the KW (prior knowledge and what they want to know) of the KWL method.

-Introduce the lesson
-Class will do hands-on activity and discuss results connecting lesson to everyday examples.

Summary:
Have the students apply the L (what they have learned) of the KWL method.

Safety: Remind students to only bring in cans with clean edges.

Clean-Up : None

Home Activity:
Have students discuss the lesson with someone at home.

Lesson Assessment:
Based on completion of activity and what they have learned (L).

Additional Activities:
Students may make several more to sell or give as gifts.

Lesson V - Plain Plane

Introduction:
One solution to cutting down on waste is to recycle. We have an abundance of plastic waste which cannot be recycled into the earth. Our landfills are few and are filling up fast.

Objectives: Students will:
-learn how to recycle materials that we ordinarily "throw away".
-find economical ways to make toys

Time Allotment: 1 week (30 mins./day)

Materials:
-plastic bottle with top, kitchen, 3 plastic tops (same size), 2 pipe cleaners, large plastic lids, 1 brass fastener, Plain Plane direction sheet.

Advanced Preparation:
Have students bring in materials prior to activity.

Procedure:
-Prior to lesson the students will apply the KW (prior knowledge and what they want to learn) of the KWL method.
-Introduce the lesson.
-Class will do hands-on activity and discuss results connecting lesson to everyday examples.

Summary:

Have the students apply the L (what they learned) of the KWL method.

Safety: Teachers may have to solicit parent volunteers because scissors are sharp.

Clean-Up: None.

Home Activity:
Have students discuss the lesson with someone at home.

Lesson Assessment:
Based on participation in activity and what they have learned (L).

Additional Activities:
Students may wish to decorate their planes. Students will have a recycled art display for the entire school.
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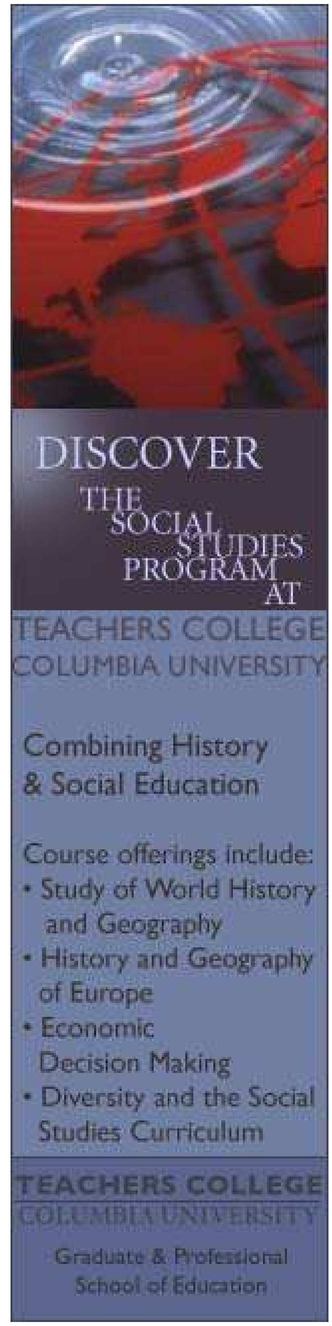

Tuesday, December 21, 1999

Throwing It All Away?

Investigating What Happens to Our Trash and Recyclable Items, and the Related Environmental Effects

Author(s)
[Alison Zimbalist, The New York Times Learning Network](#)

Grades: 6-8, 9-12
Subjects: Geography, Science
[Interdisciplinary Connections](#)

Overview of Lesson Plan: In this lesson, students investigate what happens to commonly used items and products once they are thrown away or sent to be recycled, analyzing and understanding the relationship between a product's ingredients and its effects on the environment and on the health of the living things on Earth.
Review the [Academic Content Standards](#) related to this lesson.

Suggested Time Allowance: 45 minutes- 1 hour

Objectives:
Students will:
1. Categorize what in their classroom is biodegradable, not biodegradable, reusable and recyclable; share thoughts on how a product's "ingredients" relate to the environment and to health.
2. Explore how toys containing toxins are being remade with environmental and health issues in mind by reading and discussing "Barbie and Other Toys to Go on an Oil-Free Diet."
3. Investigate, in pairs or small groups, what happens to a commonly used item once it is thrown away or sent to be recycled, including the environmental effects of this process and its results.
4. Create an illustrated flowchart or diagram demonstrating their research findings.

Resources / Materials:
-student journals
-paper
-pens/pencils
-classroom blackboard
-copies of "Barbie and Other Toys to Go on an Oil-Free Diet" (one per student)
-computers with Internet access (one per pair or small group)

Activities / Procedures:
1. WARM-UP/DO-NOW: Prior to students' arriving in class, write the following instructions on the board for students to respond to in the first few minutes of class: "Divide a piece of paper in your journal into fourths. Label each section with one of the following titles: Biodegradable, Not Biodegradable, Reusable, Recyclable. Then, look around the classroom and place as many objects as you can into these

categories. (Many objects will be able to fit into more than one category.)" After a few minutes, ask students to share their work with the class. Students may challenge others' responses and defend their ideas. Explain to students that today they will be exploring what happens to items once they are thrown into a trashcan or recycle bin, as well as examining the importance of what a product is made of in relation to the future of the environment and to the health of humans, plants and wildlife. Ask students to share their thoughts on how a product's "ingredients" relate to the environment and to health.

2. As a class, read and discuss "Barbie and Other Toys to Go on an Oil-Free Diet," focusing on the following questions:
a. Why is Barbie now not "environmentally correct," and what is being done to fix this? Why is this significant in the toy business and other industries?
b. What is polyvinyl chloride (PVC), and what risks does this chemical pose on the environment and on humans?
c. If "toys with polyvinyl chloride are safe for children of all ages," why is Mattel changing the type of plastic used in their toys?
d. What are phthalates, and what danger do they pose?
e. What types of items often contain phthalates, and why?
f. What did the National Environmental Trust find when it tested 17 kinds of bathtub and squeeze toys? How did the industry respond to these results? Do any responses surprise you, and why?
g. Why didn't the Consumer Product Safety Commission order a ban on the toxic chemical DINP?

3. Divide students into pairs or small groups of three, and assign each pair an item commonly thrown away or recycled (suggested items: rubber tires, newspapers, aluminum cans, computer components, old toys, paint, household cleaners, aerosol cans, glass, Styrofoam, scrap metal, old wood furniture). Explain to students that they will be researching what happens to their assigned items once they are thrown away or sent to be recycled, including the environmental effects of this process and its results. Each group should use the Internet to answer the following research questions about their item (written on the board for easier student access):
--Is your item biodegradable, and if so, how long does it take to fully decompose? (may be a range of time rather than an exact amount of time)
--Is your item recyclable in any way, and if so, how can it be recycled?
--Trace in chronological order what happens to your item once it is thrown away or sent to be recycled. What people are involved at different stages? Where does it go? How is the item "treated" in different places? Follow your product through to its final destination.
--What specific regulations are imposed on the disposal or recycling of this item?
--What are the environmental consequences, both positive and negative, of disposing of this item?

4. WRAP-UP/HOMEWORK: After each group completes their research, they should create an illustrated flowchart or diagram demonstrating what happens to their assigned item once it is thrown away or sent to be recycled, including the environmental effects of this process and its results. Posters should be presented and displayed in a future class.

Further Questions for Discussion:
--What does "biodegradable" mean, and what types of things are biodegradable?
--What does the phrase "Reduce, Reuse, Recycle" mean to you, and how does this phrase relate to the environment?
--In what ways do you "reduce, reuse and recycle"?
--Do you think that toys should come with product warnings and ingredients labels? Why or why not?
--What responsibilities do toy manufacturers have in labeling their products with warnings if they include an age range on their toys?
--What individual responsibility does each person have in protecting the earth?
--In what ways has an increase in technology affected our views about the importance of maintaining the earth's environment and the living things on the planet?
--Should recycling and composting be required by law? Why or why not?

Evaluation / Assessment:
Students will be evaluated based on initial journal response, participation in class discussions, group research on what happens to a product once has been used, and illustrated flowchart stemming from research.

Vocabulary:
petroleum, controversy, advocacy, ecosystems, phthalates, concentrations, carcinogen, ingest, preliminary

Extension Activities:
1. Define qualities that are linked to hazardous chemicals (including toxic, corrosive, reactive, flammable). Then, look through the chemical-based products in your home (look in your garage, kitchen, and bathroom) and chart what products possess these qualities. Create a one-page guide for your family that explains what these qualities mean, the types of products in your home that are dangerous, and what you should do if you spill, splash or ingest any of these chemicals, including important phone numbers to call for help. Post this guide on your refrigerator or other visible and appropriate place in your home.

2. Research how you can reduce, reuse and recycle in your daily life, and create a "Guide to the Three 'R's" geared towards how kids can make a difference in this way.

3. Examine how different types of plastics are made, their ingredients and their uses, including polyvinyl chloride-based plastics and plant-and-vegetable-based plastics.

4. Explore the toxins listed in the article (including petroleum, lead, cadmium and phthalates). What products contain these ingredients, and why? Where do these toxins come from? What are their benefits and hazards? What are the effects of these toxins on the human body, as well as on the environment?

5. Learn about different types of common toxins and their effects on the environment. Investigate wildlife contaminants (endocrine disrupters), persistent organic pollutants (POPs), and agriculture pollution, among others. Why are these toxins used, and what are their effects? What substitutions for these toxins are being used to ensure a healthier environment? What companies and organizations are helping in the fight against toxic chemicals on earth and in the atmosphere?

6. Conduct biodegradability experiments by composting in a small area outside of your school and monitoring what happens to the compost over time. Explore the science behind decomposition and the benefits of composting. Search the Web for how to create and maintain your own compost area.

7. Examine what carcinogens are and how they affect the human body. Learn about their sources and the regulations of these cancer-causing agents. What everyday products contain carcinogens? What danger do they pose, according to studies on them? Why are these products used if they have such dangerous effects?

8. Study how toxic chemicals and the use and disposal of non-biodegradable products affect different ecosystems. Select one ecosystem for in-depth ecological study, and propose solutions for the protection of this ecosystem.

9. Explore the environmental impact of landfills. Learn about landfills in your area, regulations imposed on them, and their expected ecological impact over time.

Interdisciplinary Connections:
Economics/Civics
-Examine the economic incentives that a toy company might have in changing their products to be more environmentally safe, as well as incentives they may have to not change such products.
-Learn about the field of "consumer safety" and the many influences that this field has on our daily consumption and product use.

Fine Arts- Create a piece of art, constructed entirely of recyclable materials, that addresses the theme of "Reduce, Reuse, Recycle."

Global History- Learn about the European Community and other country alliances that work together with regards to environmental and other concerns. What products are banned in different countries, and why? What processes must be followed to ban products? Create a map indicating your findings.

Health- Trace the effects of lead and other toxic chemicals on the human body.

Language Arts- Use the Internet to research different advocacy groups that campaign against vinyl plastics. Then, write letters to these groups that address questions that you have about the issues discussed in the article.

Mathematics- Chart statistics from the past ten to twenty years regarding recycling, landfill size, and monies involved in recycling, or create a chart examining the amount of time that it takes for different products to biodegrade.

Media Studies- Create a "Reduce, Reuse, Recycle" poster campaign geared to how students in your school can help out, and post your creations. Be sure to include statistics and other facts in each poster.

Other Information on the Web

Mattel, Inc. (http://www.mattel.com/) designs, manufactures, markets and distributes a variety of toy products on a worldwide basis.

Toys Manufacturers of America (http://www.toy-tma.org/index.html) helps enable the toy industry to freely create and market safe, fun products worldwide while recognizing its responsibilities to the well-being of children.

National Environmental Trust (http://www.igc.apc.org/eic/) functions as the resource for several major public education campaigns about environmental issues. Through a network of grassroots organizers around the country, and with attention-getting advertisements, reports, and press events, they get the word out about the importance of many environmental issues, including guarding the community's right to know about toxic chemicals.

Consumer Product Safety Commission (http://www.cpsc.gov/) is the federal regulatory agency that protects the public against unreasonable risks of injuries and deaths associated with consumer products.

Greenpeace (http://www.greenpeaceusa.org/) offers specials on climate, forests, oceans, and toxins, including Greenpeace's actions to preserve these elements of the earth, as well as a Kids' Clubhouse (located under the heading "Green.") The site also offers a report on Mattel's decision to make Barbie "environmentally correct" (http://www.greenpeaceusa.org/features/mattel.htm).

Academic Content Standards:

This lesson plan may be used to address the academic standards listed below. These standards are drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education: 2nd Edition and have been provided courtesy of the Mid-continent Research for Education and Learning in Aurora, Colorado.

In addition, this lesson plan may be used to address the academic standards of a specific state. Links are provided where available from each McREL standard to the Achieve website containing state standards for over 40 states. The state standards are from Achieve's National Standards Clearinghouse and have been provided courtesy of Achieve, Inc. in Cambridge Massachusetts and Washington, DC.

Grades 6-8

Science Standard 8- Understands the cycling of matter and flow of energy through the living environment. Benchmark: Knows how matter is recycled within ecosystems

Connect to State Standard

Science Standard 16- Understands the scientific enterprise. Benchmarks: Knows that the work of science requires a variety of human abilities, qualities, and habits of mind; Knows various settings in which scientists and engineers may work; Understands ethics associated with scientific study; Knows ways in which science and society influence one another

Connect to State Standard

Geography Standard 14- Understands how human actions modify the physical

environment. Benchmarks: Understands the ways in which human-induced changes in the physical environment in one place can cause changes in other places; Understands the ways in which technology influences the human capacity to modify the physical environment; Understands the environmental consequences of both the unintended and intended outcomes of major technological changes in human history
Connect to State Standard
Geography Standard 16- Understands the changes that occur in the meaning, use, distribution and importance of resources. Benchmarks: Understands the reasons for conflicting viewpoints regarding how resources should be used; Knows strategies for wise management and use of renewable, flow, and nonrenewable resources; Understands the role of technology in resource acquisition and use, and its impact on the environment
Connect to State Standard
Geography Standard 18- Understands global development and environmental issues. Benchmarks: Understands how the interaction between physical and human systems affects current conditions on Earth; Knows how the quality of environments in large cities can be improved
Connect to State Standard

Grades 9-12
Science Standard 8- Understands the cycling of matter and flow of energy through the living environment. Benchmark: Knows that as matter and energy flow through different levels of organization in living systems and between living systems and the physical environment, chemical elements are recombined in different ways
Connect to State Standard
Science Standard 16- Understands the scientific enterprise. Benchmarks: Understands the ethical traditions associated with the scientific enterprise and that scientists who violate these traditions are censored by their peers; Understands that science involves different types of work in many different disciplines
Connect to State Standard
Geography Standard 14- Understands how human actions modify the physical environment. Benchmarks: Understands the role of humans in decreasing the diversity of flora and fauna in a region; Understands the global impacts of human changes in the physical environment
Connect to State Standard
Geography Standard 16- Understands the changes that occur in the meaning, use, distribution and importance of resources. Benchmarks: Understands the impact of policy decisions regarding the use of resources in different regions of the world; Knows issues related to the reuse and recycling of resources
Connect to State Standard
Geography Standard 18- Understands global development and environmental issues. Benchmarks: Understands why policies should be designed to guide the use and management of Earth's resources and to reflect multiple points of view; Understands contemporary issues in terms of Earth's physical and human systems
Connect to State Standard

Send feedback on this lesson.

Browse or search the lesson plan archive.

To Recycle or Not to Recycle

A WebQuest By Deb DeFouw

Introduction:

The local town council is trying to decide whether or not to implement a mandatory recycling program. The purpose of this program is to reduce the amount of waste at the local landfill. The program would require both residents and businesses to separate their waste into garbage and material that is recyclable. Some residents and businesses are opposed to this ordinance because they do not want to have to take the time to separate their garbage. But, our local environmentalists are telling us that we are adding to much pollution to our community. They believe that if we don't act soon, we will not only be suffering from land pollution, but water and air pollution as the garbage seeps into our rivers. Members of our local council as well as some city planners are very concerned about the costs of implementing such a project. Many of the local residents are worried that they may have to incur a tax increase in order to fund this project.

The Task The Process Resources
Conclusion

Evaluation Teacher's Notes

U.S. Environmental Protection Agency

. . . to protect human health and the environment

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Regulations.gov

Quick Finder

Acid Rain	Clean Water Act	Hazardous Waste	Oil Spills	Regions	TRI
Air	Cleanup	Human Health	Ozone	Research	Wastes
Asbestos	Enforcement	Lead	Pesticides	Superfund	Water
Careers	Global Warming	Mercury	Radon	Technology	Wetlands
Clean Air Act	Grants	Mold	Recycling	Test Methods	More ...

Top Stories

Annual listing of fish advisories issued Aug 24 - EPA released its 12th annual summary of information on locally-issued fish advisories and safe-eating guidelines. The number of advisories issued continues to rise as states expand their testing programs.
News release | More ...

Los Angeles to pay $2 billion for sewage spills Aug 6 - The sewage case is one of the largest in history, with more than 4500 spills over past decade. Under the settlement, the city will rebuild some sewer lines and clean others, increase capacity, and plan for future expansion.
News release

Mobil to pay over $5.5 million for Clean Water Act violations on Navajo lands Aug 3 - Mobil will reduce the number of oil spills and build a drinking water pipeline to provide water to 17 remote residences located on the oil production fields. Currently, local residents drive up to an hour for drinking water.
News release

Largest-ever grant to study health effects of air pollution July 29 - Administrator Mike Leavitt awarded the University of Washington a $30 million grant to study the connection between air pollution and cardiovascular disease. The grant is the largest ever awarded by the EPA for scientific research.
News release | More ...

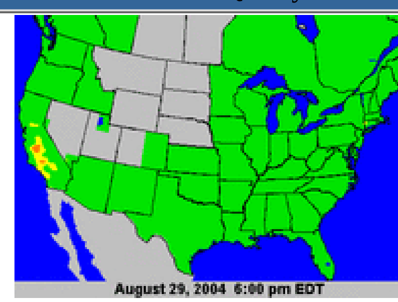
EPA Administrator

Mike Leavitt's Web page
Enlibra principles
Biography
Speeches
Recursos en Español

Children and Lead

Information for parents of children exposed to lead in drinking water, paint, or other sources.

Your Air Quality



Good	Moderate	Unhealthy for Sensitive Groups
Unhealthy	Very Unhealthy	Hazardous
No data available		

More information

Other News

National	Nine sites added to National Priorities List
National	Great Lakes Executive Order
Consumer	First hybrid SUV certified for sale in US
Northeast	New England's Best Workplaces for Commuters
CA	United Airlines to resolve hazardous waste violations
DC	New safeguards for lead in drinking water
ID	Erosion control complaint against Transportation Dept
MA	PCB Cleanup Facility opens in New Bedford Harbor
ME	EPA seeks air penalties from Maine Military Authority
NH	$4 Million for cleanup at NH Plating Superfund site
NJ	"Coastal Crusader" guards NJ beaches
NY	2-story lab demolished at Superfund site
NY	Clean School Bus grants to benefit 50,000 kids
PA	Enforcement wins vinyl chloride emissions reduction
PR	Vieques draft community involvement plan released
UT	PacifiCorp to clean up contamination in Salt Lake City

All EPA news releases

News Updates by Email

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In Your Classroom
Learn about issues
Try some games
More ...

While At Work
Commute smart
Reduce energy use
Reduce/reuse/recycle
More ...

Popular Resources

Common Questions	Libraries
Staff directory	Publications
Hotlines	Glossary & Acronyms
TTN	Databases & software
Dockets	Federal Register
Summer Tips	Other resources

Summer Travel Tips

More Americans than ever are hitting the road this summer. Conserving fuel is increasingly important to our environment and, with higher gas prices at the pump, our wallets as well. Drivers can take a number of steps to minimize trips to the fuel pump and to protect the air we breathe: drive wisely; maintain your car; plan trips in advance; and don t top off your gas tank.
More ... | Más

Highlighted Program

Clean Air Rules of 2004

The Clean Air Rules are a suite of actions that will dramatically improve America's air quality. Three of the rules specifically address the transport of pollution across state borders. These rules provide national tools to achieve significant improvement in air quality and the associated benefits of improved health, longevity and quality of life for all Americans.
More ...

Test Your Enviro-Q

Being Sunwise: What ratio of Americans will develop skin cancer in their lifetime?

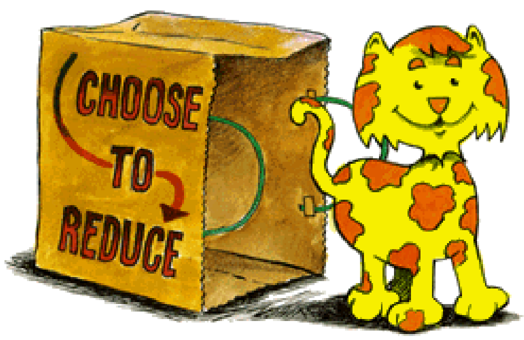
a. One in five
b. One in ten
c. One in a hundred
d. One in a thousand

Answer
Previous questions

Emergencies

Spills or releases of oil or chemicals should be reported immediately to the EPA Spill Hotline: 800-424-8802.

The Consumer's Handbook for Reducing Solid Waste



The Cat's Out of the Bag! This site describes how people can help solve a growing problem...garbage!

Individual consumers can help alleviate America's mounting trash problem by making environmentally aware decisions about everyday things like shopping and caring for the lawn. Like the story that says that cats have nine lives, so do many of the items we use every day.

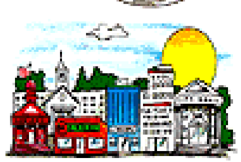
Reusing products is just one way to cut down on what we throw away. This web site outlines many practical steps to reduce the amount and toxicity of garbage. These aren't the only steps that can be taken to reduce waste, but they're a good start.

The Problem Is Too Much Trash

Learn why trash has become a major problem today.

Source Reduction: A Basic Solution

Source reduction is waste prevention: less waste means less of a waste problem.
Get the facts.



Making Source Reduction Work

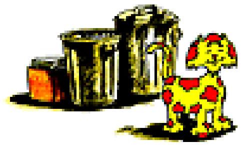
Learn what we can do to prevent solid waste build-up, and read about a few success stories.

The Four Basic Principles

Find out what it means to reduce, reuse, recycle and respond.

The Twelve Tips

You can start reducing waste right now.
Twelve easy-to-follow tips for waste prevention.



Conclusion

So what have we learned?

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Superfund for Students and Teachers

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Test Your Knowledge
Classroom Activities
Health Information
Environmental Careers
Links
Earth Day Info
National Geography Week

HAZ-ED - Classroom Activities for Understanding Hazardous Waste

Hazed materials can be used as part of a larger curriculum, as special stand-alone activities, or on an occasional basis to teach students about hazardous waste issues. Hazed is a compilation of interdisciplinary activities that focus on the often complicated and sometimes controversial scientific, technical, and policy issues related to hazardous waste sites and Superfund. It is designed to help students develop skills in critical thinking, problem solving, and decision making. It also increases environmental awareness and encourages an environmental ethic in students.

The Table of Contents can be utilized in sequential order, or the Introduction further defines the components of the materials which will enable teachers to design their own organization for the Hazed activities. The materials focus on grades ranging 7th through 12th, the Warm-Ups and Activities specifically list the appropriate grade level. All materials listed are linked to a PDF format in addition to the web enabled format.

About PDF

Table of Contents

- **Foreword**—This includes an Introduction, Instructional Goals, and detailed instructions on how to use the Hazed material. **[PDF format, 11 pages, 127KB]**

- **Warm Up Exercises**—The Warm-Ups focus on developing and understanding some basic concepts related to hazardous waste.

- **Activities**—The Activities build on the Warm-ups, although they can stand alone. Students examine issues related to hazardous waste and site cleanup.

- **Fact Flashes**—The Fact Flashes are a set of fact sheets that provide the foundation of information on which the Warm-ups and Activities are built.
- **Glossary**—The Glossary defines many of the terms and concepts students will encounter in the exercises and activities. **[PDF format, 10 pages, 27KB]**
- **Suggested Reading**—A list of abstracted Suggested Readings provides both educators and students with additional information. **[PDF format, 8 pages, 146KB]**
- **Contacts and Resources**—This page provides a variety of information, including key phone numbers and Internet addresses. **[PDF format, 4 pages, 209KB]**
- **This Is Superfund Brochure —** This is a stand-alone document that describes the Superfund Program. **[PDF format, 8 pages, 524KB]**
- **Bibliography**—This page lists resources used in preparing the Haz-Ed materials. **[PDF format, 2 pages, 48KB]**

Warm-Up Exercises

1. **Defining Hazardous Waste:** Students define and explore the relationship between hazardous substances and hazardous waste. Grade level 7-10 **[PDF format, 4 pages, 145KB]**
2. **EPA's Superfund Program:** Students learn about the goals of the Federal Superfund Program and how these goals are achieved. Grade level 7-12 **[PDF format, 10 pages, 282KB]**
3. **The Numbers Game:** Students gain an appreciation for the part-per-million and part-per-billion units used to measure contaminant concentrations in the environment. Grade level 10-12 **[PDF format, 10 pages, 266KB]**
4. **Risk Concepts:** Students explore the meaning of risk through a simple exercise in probability. Grade level 7-10 **[PDF**

format, 6 pages, 421KB]

5. **Hazardous Waste Issues in the News:** Students conduct research to collect news media reports on local and national hazardous waste issues. Grade level 7-12 **[PDF format, 10 pages, 236KB]**

6. **What is an Aquifer?:** Students build a simple model of an aquifer to study the relationship of groundwater and surface water and explore the ways contaminants are spread through water. Grade level 7-9 **[PDF format, 4 pages, 128KB]**

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Activities

1. **Waste: Where Does It Come From? Where Does It Go?:** Students identify and locate on a map the potential sources of hazardous waste in their neighborhood or community. Grade level 9-12 **[PDF format, 4 pages, 152KB]**

2. **Examining a Hazardous Waste Site:** Students begin to understand how Superfund sites are created. Grade level 9-12 **[PDF format, 8 pages, 196KB]**

3. **Companion to Superfund-the Resource Conservation and Recovery Act (RCRA) Program:** Students explore the nation's program for properly managing and disposing of hazardous and nonhazardous waste in the United States. Grade level 9-12 **[PDF format, 6 pages, 218KB]**

4. **Dealing with Chemical Emergencies:** Students discover how Federal, state, and local authorities respond to chemical emergencies under Superfund and other laws. Grade level 7-12 **[PDF format, 6 pages, 207KB]**

5. **How Hazardous Substances Affect People:** Students gain an appreciation for how scientists determine the human health effects of hazardous substances. Grade level 7-10 **[PDF format, 5 pages, 234KB]**

6. **Examining the Effects of Pollution on Ecosystems:** Students learn that hazardous waste may have far-reaching impacts on ecosystems that are not-always easy to identify. Grade level 10-12 **[PDF format, 16 pages, 588KB]**

7. **Identifying Risks at a Superfund Site:** Students begin to understand the types of risks found at Superfund sites and how these risks are identified and assessed. Grade level 7-12 **[PDF format, 8 pages, 313KB]**

8. **Hazardous Waste Cleanup Methods:** Students explore some of the reasoning involved in choosing technologies for cleaning up hazardous waste sites. Grade level 9-12 **[PDF format, 4 pages, 122KB]**

9. **Making Decisions About Hazardous Waste Cleanup:** Students assume roles and act out a situation that illustrates the process of decision making during cleanup of a Superfund site. Grade level 9-12 **[PDF format, 18 pages, 951KB]**

10. **Pollution Prevention:** Students discover what can be done to reduce the amount of solid and hazardous wastes that must be disposed of and managed safely. Grade level 7-12 **[PDF format, 8 pages, 366KB]**

11. **What the Community Can Do:** Students learn how the U.S. Environmental Protection Agency involves communities near Superfund sites in the cleanup process, and the types of activities communities can use to influence how hazardous waste sites are cleaned up. Grade level 7-12 **[PDF format, 6 pages, 149KB]**

12. **Federal and State Laws on Hazardous Waste:** Students will become familiar with how laws affecting hazardous waste are developed, enacted, implemented, and enforced. Grade level 7-12 **[PDF format, 8 pages, 258KB]**

13. **Creating the Future:** Students create and write scenarios for the future related to hazardous waste pollution. Grade level 7-12 **[PDF format, 4 pages, 138KB]**

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Fact Flashes

1. **Hazardous Substances and Hazardous Waste:** Students learn how chemicals affect our everyday lives. **[PDF format, 1 page, 345KB]**

2. **The Superfund Cleanup Program:** Students learns how EPA deals with abandoned, accidentally spilled, or illegally dumped hazardous substances from the past. **[PDF format, 4 pages, 264KB]**

3. **Flowing Railroad Hazardous Waste Sites:** Students learn how a Railroad yard became a 25-acre waste site. **[PDF format, 6 pages, 343KB]**

4. **Flowing Railroad Site Investigation Results:** Students learns how EPA investigated this site and what the results were. **[PDF format, 2 pages, 235KB]**

5. **Groundwater :**Students learns what groundwater is, how it is contaminates, and how it is cleaned. **[PDF(a) format, 3 pages, 344KB] [PDF(b) format, 3 pages, 271KB]]**

6. **Resource Conservation and Recovery Act (RCRA):** Students gain an understanding of RCRA and how it works. **[PDF format, 4 pages, 295KB]**

7. **Pollution Prevention:** Students learns numerous ways to prevent pollution. **[PDF version, 4 pages, 238KB]**

8. **Common Cleanup Methods:** Students learn how effective various methods of cleanup are and why they are used. **[PDF version, 6 pages, 326KB]**

9. **Common Contaminants:** Students learn about common contaminants, where they are found, and how they can affect human health. **[PDF version, 18 pages, 246KB]**

10. **Superfund Community Involvement Program:** Students understand why community involvement is essential in all Superfund actions taken by EPA. **[PDF version, 4 pages, 249KB]**

11. **Other Major Environmental Laws:** Students study a series of environmental laws and how they work together to protect our health, our environment, and our future. **[PDF version, 4 pages, 254KB]**

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Inside many of the buildings in Recycle City you'll find information on recycling, reuse, and waste reduction.

Explore this area of the city by clicking on different items and buildings. Find out what's being done to improve the environment for everybody!

First Visit? | Go to Recycle City! | What's New | About Recycle City's Founders | EPA Region 9 Home

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U.S. Environmental Protection Agency

Educational Resources

Recent Additions | Contact Us | Print Version Search:

GO

EPA Home > Wastes > Educational Resources > Kids > Activities > Recycle Bin Game

Educational Resources
Kids (K-5)
Students (6-8)
Teens (9-12)
Teachers
Photos
Researchers
Careers

Which Bin Does It Go In?

You must have the Macromedia Authorware Web player on your computer in order to play the game. Get the player from Macromedia. After the plug-in installer has completed refresh your browser.

Welcome to the Recycling game. Drag and drop the trash from the conveyor belt to the correct recycling bin before any of the items fall into the trash can. If you make it through the first minute the conveyor will speed up and move faster and faster.

Click the Bin to Begin Playing
Close the game window when you're done.

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HOW TO PLAY:

Read the clue. Find the number on the puzzle that matches that clue. Using your mouse, click inside of the first block for that clue and type a letter. Tab or click inside of the next block until you have completed the entire word.

CHECKING YOUR ANSWERS:
To check your answer, simply click on the number button that matches your clue.

Good Luck!

Across

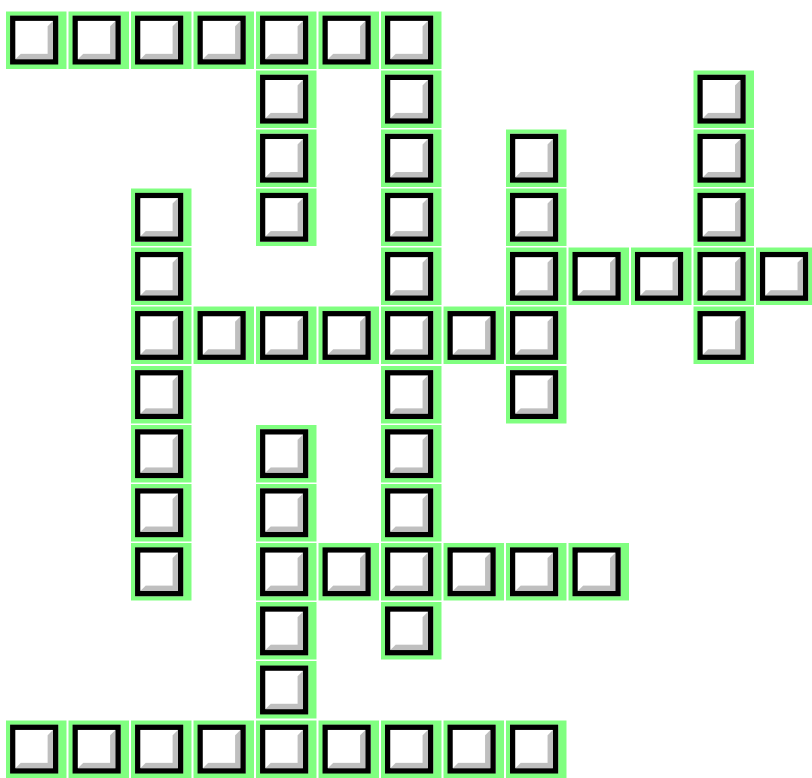
1. A product can be considered __________ when it lasts a long time.

7. To use something again for the same purpose or a new purpose.

8. What a pile of decayed food scrapps, leaves and grass turn into.

10. You can ________ old toys to needy children instead of throwing them away.

11. Comes in disposable and rechargeable varieties.



Clear

Down

2. If you buy one large bag of potato chips instead of five small bags, you are buying in ______.

3. Your world, surroundings, and source of life and health.

4. Many items found in your ________ can be recycled into valuable new products.

5. Fossil fuels, such as coal, oil, and natural gas that are used to manufacture products and heat our homes, come from the ________.

6. To collect used materials to make into new products rather than throwing them away.

9. To decrease the amount of trash you throw away.

cleaning water the way nature does

Explore an ecological wastewater recycling system in [Chatham County, North Carolina], at the former Triangle School.

Wastewater is cleaned for reclamation and reuse using constructed wetlands, and a greenhouse containing soil filters and an aquatic ecosystem. This is the first on-site treatment facility of its kind in North Carolina which not only purifies water and reclaims nutrients, but also reuses water, and therefore RECYCLES WATER. Nutrients from the wastewater are captured to be used later as fertilizer for landscape plants.

The Triangle School Wastewater Treatment Facility was designed by a team headed by Halford House at North

guided tour

alternative wastewater treatment overview

triangle school wastewater treatment system

photographs & construction

table of contents

bibliography & world wide web links

Carolina State University (NCSU). Faculty and students from NCSU and other universities will be conducting research at the site, while students from the Chatham County Public Schools and children at the Exploris Museum will soon be able to study the site, suggest experiments and interact with researchers via the internet.

Take the guided tour to visit the highlights of this site.

Contact us at info@waterrecycling.com

Click here to visit the AWWA (American Water Works Association)

Site designed and hosted by Blast Internet Services.

For best viewing of our site use one of these browsers.

First Nations History Theme Page

This "Theme Page" has links to curricular resources (information, content...) to help students/teachers learn about the History of First Nations People. Please read our disclaimer.

- ## BC Ministry of Aboriginal Affairs: Historical References

  A brief summary of British Columbia's history as it touches upon Aboriginal affairs.

- ## Canada-Indian Treaties

  This section of the National Atlas Information Service provides maps showing areas covered by treaties from pre-Confederation to 1923. A table gives details of treaties, including parties involved. The map is at scale 1:7 500 000.

- ## Canada's Native Peoples

  This is Volume II of the Canada Heirloom Series containing eight chapters, each giving a history of Native Groups within a region of Canada. Chapter cover the history of Aboriginal life in Cape Breton, St. Lawrence Lowlands, Woodland, Plains, NWT/Yukon/BC, Arctic, Metis, and Northwest Coast.

- ## Canadian Museum of Civilization: First Peoples Hall/Archeology Hall

  Over a dozen exhibits on the history and culture of First People in Canada including the Arctic.

- ## Explorers Theme Page

  This page contains some resources that look at the exploration of the New World from the First Nations' perspective.

- ## First Nations Histories

  This site has histories of approximately 240 tribes (from first contact to 1900). Although the tribes will be primarily from the U.S., First Nations from Canada and Mexico that had important roles (Huron, Micmac, Assiniboine, etc.) will be included. Documents on tribes has information in the following categories: location, population, names, language, sub-nations, villages and bands, current groups, culture, and history.

- ## First Nations Territories of the Pacific Northwest

  This subsection of "The Northwest Connection," a Website focusing on Native art, provides a condensed history of the Northwest Coastal people with an emphasis on their cultural history.

- ## A Historical Look at Canada & B.C.'s Relationship With First Nations

  A brief timeline of major events in BC with a First Nations impact.

- ## [A] History of the Northwest Coast

  A collection of excerpts from journals during the European/Indian contact period on the NW

Coast.

- [Hudson's Bay Digital Collection]

  Images of the Hudson's Bay Company's museum collection donated to the Manitoba Museum of Man and Nature. Resources are organized within Ten categories, including Inuit, Aboriginal, and Metis cultures.

- [Information about Innu History and Culture]

  About fifty articles/resources on the history of the Innu (formerly known as Montagnais or Naskapi) of eastern Quebec and Labrador.

- [Masks Theme Page]

  These CLN Theme Page has a number of links on the First Nations' use of masks. See in particular, Masks.org, Richard Hunt, and the U'Mista Cultural Centre Potlatch Collection.

- [Native American History Resources on the Internet]

  A meta-list of links to Websites/resources dealing with Aboriginal history. Note: many of the meta-list's sites that would be of interest to Canadian students are already present on this theme page.

- [Native Soldiers, Foreign Battlefields: The Wartime Contribution of Canada's First Peoples]

  In producing this publication, Veterans Affairs Canada hopes that Canadians, particularly those who are learning about Canadian history in the classroom, will gain a better understanding of the contribution of Aboriginal veterans to this nation's wartime response.

- [Nisga'a History]

  A document summarizing the history of the Nisga'a of the Nass River valley in Northwest BC.

- [North: Landscape of the Imagination]

  The National Library has drawn on its collection of books, magazines, manuscripts and music to reveal the North of the artist. The collection...lends itself naturally to the retelling of one strand of northern history - the North as experienced and recreated through the imagination of its artist.Click the button above to browse through the entire site, or go directly to the historical resources below. Each of these resources has links to other relevant National Library historical documents.

  - Pre-contact: Before 1500
  - Early History: 1500 to 1900
  - The First Half of the 20th Century

- [Our Elders: Interviews with Saskatchewan Elders]

  Developers of this site hope to promote cultural awareness and provide younger generations with access to a history that may otherwise be inaccessible. This Website includes a searchable database of images and information provided in the interviews.

- Stories, Folklore, and Fairy Tales Theme Page

  This CLN Theme Page has links to a number of resources/lessons on First Nation legends.

- Miawpukek Aknutmaqn

  When the early European explorers arrived in our land, the (French) initially referred to our people as Sourquois and later as Mi'kmaq; we call ourself Inu (Human Being). Our nation consists of the areas now known as New Brunswick, Maine, Quebec, Nova Scotia, Prince Edward Island and Newfoundland. For historical information, click on "history" and "historic photos."

Top of Page

Note: The sites listed above will serve as a source of curricular content in First Nations History. For other resources in Aboriginal Studies (e.g., curricular content, lesson plans, and theme pages), click the "previous screen" button below. Or, click here if you wish to return directly to the CLN menu which will give you access to educational resources in all of our subjects.

Previous Screen

ASTEROID AND COMET IMPACT HAZARDS

8/29/2004

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NEO Catalog ►
NASA Programs ►
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To request information on this web site in a Section 508 accessible format, please contact us here.

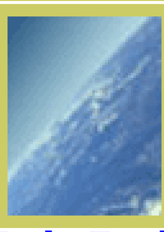
News in Brief

News Archive

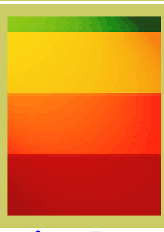
August 26,2004
Closest Asteroid 2004 FU162
Last March 31 a very small asteroid passed Earth at an altitude of only about 6500 km above the surface. Read more...

August 19,2004
Don Quijote, Toutatis, and & Sagan
(1) A European mission to move an asteroid, (2) a close (but safe) pass by a large asteroid, and (3) the DPS Sagan Medal for public outreach. Read more...

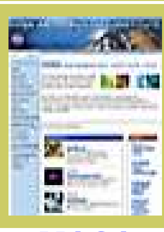
Related Information



Is the Earth targeted for impact?



Torino Impact Scale



NASA Astrobiology Institute

NASA NEO Program Office

Tumbling Stone

UK Near Earth Objects

Questions and Comments
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Request information on this web site in a Section 508 accessible format

BUILD YOUR OWN COMET

Active Learning Exercises in Planetary and Solar Astronomy

Copyright 1996
National Optical Astronomy Observatories
Volume 2, Number 1

INTRODUCTION

This exercise was presented as part of a NASA IDEA grant titled *Active Learning Exercises in Planetary and Solar Astronomy for K-3 Students*. NOAO astronomers worked with students and teachers of the Satori School in Tucson, AZ, to present eight topics in the elementary classrooms. This writeup is intended to be a resource for other astronomers venturing into classrooms. It describes our experiences presenting the classic "Build Your Own Comet" exercise and includes additional facts about comets that might be useful to astronomers who don't specialize in this field.

For more information on this module, or others developed through this program, contact the NOAO Educational Outreach Office at outreach@noao.edu.

DESCRIPTION:

This was the second of four presentations made to students on the topic of planetary astronomy. It was the most exciting and talked about of the presentations, but care has to be taken to minimize misconceptions. This activity is useful and fun for all grade levels, with the presentation tailored to the age and interest of the students. In each class, the expected learning outcomes included:

- the composition of comets
- why comets have a tail
- the size of comets

Depending on the age of the students and the teacher's comfort level with the materials, students can also be expected to understand:

- the process of sublimation (going from a solid phase directly to a gas phase)
- the orbits of comets
- the differences in comets, asteroids, and meteoroids
- the concepts of radiation pressure and solar wind, and why a comet's tail is always pointing away from the sun (anti-sunward).

To demonstrate these concepts, we started with an interactive slide show of comet images with lots of questions and discussion. In our discussion, we compared and contrasted planetary orbits and the orbits of comets. After students understood something about cometary orbits, they could draw conclusions about why we see a given comet only once over a period of many years. We then compared the size and composition of asteroids, planets, and comets. In our slide show, students were encouraged to observe the comet tail in each picture. We had the students hypothesize as to why comets have tails and why the tails get longer as the comet approaches the sun in its orbit. We then had each class create a "comet" from pans of materials. Students worked in groups of four, with one adult per group.

Safety: Students will be working with dry ice and ammonia. Both of these materials must be handled responsibly. Depending on the age group you are working with, you need to decide if the students can pour the ammonia and work with the dry ice themselves. If each student has a pair of rubber gloves, the danger of dry ice burns is minimized. For younger students, an adult should be in charge of the ammonia to minimize risks.

We used a comet recipe developed by Dr. Dennis Schatz of the Pacific Science Center, found in the Project ASTRO Universe at Your Fingertips Resource Book, which is available from the Astronomical Society of the Pacific. The recipe is also available on-line from the K-12 Educational Outreach Activities link on the NOAO Home Page.

The original recipe, as given on the last page of this brochure, makes a 6 inch comet. We had good results cutting all ingredients in half, making the final comets smaller in size and easier for the elementary students to handle. It worked best when each student had their own pair of rubber gloves. The recipe was pretty reliable: if the comet didn’t compact well enough, just adding a bit more water and squeezing harder always made it come together. We also displayed a poster board whole-language recipe card for the students to follow along as the groups assembled their comets.

Most real comets have a much higher ratio of "dirt" than the student comets. Halley's Comet has about 50% dirt. Because of the high dirt content, comets are very dark and absorb a lot of light. The students' comets will not be dark because this recipe does not work well with the higher ratio of dirt.

The most common misconception was that real comets contained Karo syrup, the ingredient used in Dr. Schatz’s recipe to represent organic materials. Although it was pointed out that Karo Syrup only represented the sort of molecules found in comet nuclei, post-testing showed several students misunderstood this point. Next time, we would pour the syrup out of an intermediate container, rather than pouring it directly out of the bottle in view of the students.

COMET FACTS:

These facts about comets are contributed by NOAO/NASA Scientist, and IDEA Grant participant, Dr. Nalin Samarasinha.

A comet consists of the following parts:

- **nucleus** - a comet's distinct center
- **coma -** a hazy cloud of gas and dust that surrounds the nucleus (The comet head consists of both the nucleus and coma.)
- **tail -** the coma, pushed by radiation pressure and solar wind away from the nucleus

Ices in the nucleus of a real comet sublimate as they approach the sun. The gas and dust released during this process form the coma. Solar radiation pressure pushes the dust away from the sun forming a dust tail, while solar wind (and associated magnetic field lines) causes the cometary ions to form a plasma tail. The tail of a comet will always be anti-sunward (away from the sun), not opposite the direction of comet motion. The gasses produced during the demonstration are representative of sublimation, going from a solid state directly to a gas phase (state), Students can discuss the three phases of matter: solid, liquid, gas, and the changes between these states.

According to the *"Catalogue of Cometary Orbits 1993"* there were least 855 individual comets observed until that year, with 174 of them being short period comets, that is, periodic comets with periods less than 200 years. Comet Halley and Comet Encke are examples of short period comets. Comet Halley has a period of 76 years.

The following physical properties of comet nuclei are based mainly on observations of periodic comets:

- Typical albedo (the fraction of incident sunlight that is reflected back is few percent. That is, comets are dark and good absorbers of light. Therefore, the surface of a typical short-period cometary nucleus most probably consists of a dark mantel (crust) made up of dust grains with few active areas (vents). The outgassing is mainly confined to these active areas. (Note: Do not confuse the surface mantel of the comets with the refractory organic mantels of the dust grains; crust may be a better word for the cometary mantels).
- Typical radii are of few kilometers (Halley is relatively large at about 5.2 km). Chiron has a radius of about 90 km and is currently the largest known comet.
- Comets are not round, they are elongated (e.g., peanut shaped). Further, they are not smooth. Just like the students' samples, comets are rough and have vents where the gasses escape.
- Indications for density imply less than 1 gram/cm3. Note that density is never

measured directly, but inferred based on mass estimates derived from non-gravitational forces caused by sublimation.

Chemical composition of the nucleus by number, based on coma observations:

- H_2O ice is the main component (80-90%). CO ice is next with 7-15%. The other major parent molecules include CO_2, CH_4, NH_3, N_2, H_2CO (formaldehyde), and HCN.

Ultimately, all of a comet's light comes from the sun, either from the scattering of radiated sunlight by dust particles or the reemission of absorbed sunlight by gas molecules as fluorescence.

The corn syrup in the recipe is representative of organic compounds found in comets. Organics are carbon based molecules, molecules which are common to all known forms of life.

The coma of bright comets extends well over 100,000 km. The Hydrogen coma extends well over 1,000,000 km from the nucleus. The coma can be approximated as spherical. Typical speeds of molecules in the coma exceed 1 km/sec. Also, a cometary coma is thinner than the best vacuum we can produce on earth (except when very close to the cometary nucleus).

Outgassing rates: For Halley, each orbit, it sheds about 1 meter of its surface. The peak production of water near the perihelion is about 30,000,000 grams/sec (30 tons per sec). Also, the outgassing gas carries dust grains with it (For Halley, the dust to gas ratio is about 1; for other comets it can be easily differ by factors of a few or even by an order of magnitude).

ACKNOWLEDGMENTS:

Support for this work was provided by NASA through Grant number ED-90020.01-94A from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555. This work was carried out through the Educational Outreach Office of the National Optical Astronomy Observatories (NOAO). NOAO is based in Tucson, AZ, and operates facilities for ground-based astronomical research including Kitt Peak National Observatory near Tucson, the National Solar Observatory, with facilities on Kitt Peak and on Sacramento Peak in New Mexico, and the Cerro Tololo Inter-American Observatory in Chile. NOAO is operated by the Association of Universities for Research in Astronomy, Inc., under agreement with the National Science Foundation. This brochure was produced in February, 1996, by the NOAO Educational Outreach Office, P.O. Box 26732, Tucson, AZ, 85726.

COMET LINKS:

For further browsing you may begin with the following sources:

- Bill Arnett: Comets

- Sky & Telescope Comet Page
- JPL: Small Bodies

Support for this work was provided by NASA through grant number ED-90020.01-94A from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Incorporated, under NASA contract NAS5-26555.

Page created and maintained by outreach@noao.edu

The page "**toc.html**" no longer exists. Please update your bookmarks. You are being redirected to our home page in 5 seconds.

About the Regional Geophysics Section (RGS)

Aeromagnetic and gravity data are the nucleus of Regional Geophysics' activities. New data is acquired and standardized to the national data bases, and customized products (digital and paper) are distributed. Analytical methods for the enhanced application of magnetic and gravity data are developed and the data is applied to the resolution of geoscience problems.

The ability to map the third dimension, to determine structure and rock type at depth, makes geophysics, and specifically magnetic and gravity data, fundamental to our advancing knowledge of the Earth.

Programs

Data Coverage

Programs

The key components of the section are:

- Aeromagnetic Surveys - current projects and acquisition standards.
- Geophysical Applications - analytical methods and geoscience applications.
- Geophysical Data Centre - aeromagnetic and gravity data sales.

Data Coverage

For information on **Aeromagnetic and Gravity** data coverage and how to order maps and data :

- consult the Geophysical Data Centre's Catalogue of Products and Services.

2000-12-05 Important notices

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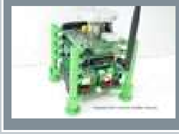
ASTRONOTES



Hands-on Satellite Teaching Tool
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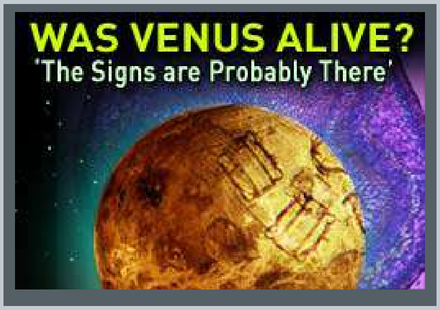

- Expedition 9 Crew Prepares for Final Spacewalk
- Outside Firm Says NASA's Culture is Improving
- NASA Cites Progress in Columbia Board Recommendations
- 'Blade Runner', Asimov, Top Scientists' List of Fave Films, Authors
- 'Super Earth' Discovered at Nearby Star
- NASA Extends Mars Odyssey Orbiter Mission
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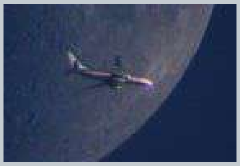
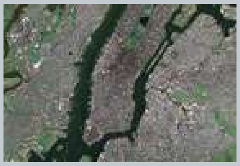


Image of the Day: Fly Me Past the Moon
Amateur astronomer Dan Bush was experimenting this summer with taking pictures through his telescope of high-flying airliners.



Heart of the Country: New York City
Zoom in and View a satellite image of the Big Apple, where the Republican National Convention will be held next week.

New Wallpaper: Cool Views of Earth
Check out the best shots of the Home Planet from Space!

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XML What is This?

Meteorite and Impacts Advisory Committee

to the Canadian Space Agency.

Comité consultatif sur les météorites et les impacts

de l'Agence spatiale canadienne.

The **Meteorites and Impacts Advisory Committee (MIAC)** to the Canadian Space Agency is a volunteer group of geologists and astronomers which serves as the coordinating body for meteorite and impact reporting and research in Canada.

Search this site

Le **Comité consultatif sur les météorites et les impacts (CCMI)**de l'Agence spatiale canadienne est un groupe bénévole de géologues et d'astronomes qui coordonne les informations et la recherche sur les impacts et les météorites au Canada.

Faire les recherches

Meteorites

Météorites

Want to know more about meteorites? Look at our images and descriptions.

Vous voulez en connaître plus sur les météorites? Regardez nos images.

- Introduction (English)
- Meteorites - introduction
- Iron meteorites
- Stony meteorites
- Antarctic meteorites

Meteorites in Canada and elsewhere

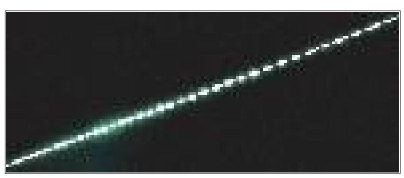
- Compact Catalogue of Canadian Meteorites
- Catalogue of Canadian Meteorites
- Meteorite Collections in Canada
- Guide for Meteorite Identification and Collection
- The St. Robert meteorite and its fall, 14 June 1994
- Export of meteorites from Canada: Legal aspects
- NEW! Prairie Meteorite Search

- Introduction (français)
- Météorites - introduction
- Météorites ferreuses
- Météorites pierreuses
- Météorites de l'Antarctique

Météorites au Canada et ailleurs

- Catalogue compact des météorites canadiennes
- Catalogue des météorites canadiennes
- Collections de météorites au Canada
- Guide pour la collection et l'identification de météorites (à venir)
- La météorite de Saint-Robert et sa chute, 14 juin 1994
- Exportation des météorites de Canada : aspects légaux

Fireballs



Étoiles filantes et météores

- Have you seen a bright fireball? Then use our Fireball Reporting Form
- A Compilation of fireball reports is maintained at Mount Allison University
- NEW! Fireball data from the fireball network
- Want to know more about the link between fireballs and meteorites?
- A guide to terms used in the Canadian Fireball database
- Images of the Canadian Meteorite

- Avez-vous vu une météore brillante? Vous pouvez la rapporter à l'aide de notre Formulaire de rapport d'étoiles filantes et de météores
- Une compilation de rapports d'observations d'étoiles filantes et de météores est gardée à l'Université Mount Allison.
- Vous voulez en connaître plus sur le lien

Observation and Recovery Program

- Computation of the trajectory of a fireball from eyewitness accounts
- NEW! North American Fireball Camera Network

entre les météores et les météorites ?

- Images du projet canadien d'observation et de récupération de météorites

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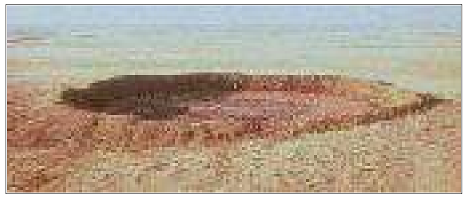
Impact Structures



Structures d'impact

- Research on Meteorite Impact Structures (to come)
- Chicxulub crater, Mexico
- Images of impact structures
- We also have simulations of the formation of craters (courtesy Michel A. Bouchard, Université de Montréal) MPEG 10 seconds; 130 kb
- Want to know more about impact craters throughout the world? See the World Impact Database

- Recherche sur les sites d'impact de météorites et de comètes (à venir)
- Cratère de Chicxulub, Mexique
- Images des structures d'impact terrestre Nous avons aussi les animations de formation des cratères (une gracieuseté de Michel A. Bouchard de l'Université de Montréal) MPEG 50 secondes; 796 kb
- Vous voulez en connaître plus sur les cratères d'impact partout dans le monde? Regardez le World Impact Database (en anglais).

Miscellany

- Essential reading
- Links to others web sites
- IBM Cratering screen-saver (zip file)
- MIAC - forms, meeting, etc
- Meteorites?

Divers

- Liste des livres sur ce sujet
- Liens aux autres sites Web
- Économiseur d'écran IBM (fichier zip)
- CCMI - formulaires, réunion, etc
- Météorites?

Meteorites

Mail comments to / Envoyez vos commentaires à Michael Higgins

Repertoire de Michael Higgins home page

Last updated: jan 10, *2002*
Dernière mise à jour: 10 *jan, 2002*

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Sky & Telescope Logo Items
Sky & Telescope Magazine
Software

Asteroids

Although some might call them the "vermin" of the solar system, asteroids are rocky little worlds that are just as fascinating and mysterious as many of their larger planetary cousins.

[Student's Asteroid Project Wins Intel Award]

A high-school junior studying asteroids has won the country's most prestegious science fair award.

[Hunting Asteroids From Your Backyard]

You can discover an asteroid tonight. Digital technology and the CCD revolution have given amateurs the ability to do it. Here's how.

[Asteroid Hunters Receive Grants]

In July, 2002, five amateur astronomers specializing in the observation and early detection of Earth-crossing asteroids and comets were each awarded Shoemaker Grants.

[The Benson Prize]

If saving the Earth from destruction isn't enough incentive to find near-Earth asteroids, there's a prize for the amateur who discovers one.

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Home > Observing > Celestial Objects > Comets

NEWS

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- Sky at a Glance
- Observing Highlights
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- Image Gallery

HOW TO

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Comets

Of all celestial objects, comets have a very special mystique. Bright ones are rare but on any given night at least one comet is likely to be within reach of moderate amateur telescopes.

[2004 Comet Award Winners](#)
Two Australians will share the sixth annual Edgar Wilson Award for amateur comet discovery.

[How to Estimate a Comet's Brightness](#)
Comets are notorious for not being easily predictable, but even judging the magnitude of a bright comet that's right in front of you is not straightforward.

Magazine

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[Secrets of High-Power Comet Observing]
Although bright comets are infrequent visitors to our skies, faint comets appear regularly. Here are some observing hints that will make your comet-watching more enjoyable.

[Comet Photography for Everyone]
Regardless of equipment or skill level, with a little planning everyone who tries should be able to photograph bright comets.

[How Yuji Hyakutake Found His Comet]
Ever wonder how somebody actually finds a comet, and what happens when he does? Here's one astronomer's story.

[How to Report a Comet Discovery]
So you think you've found a comet? Here are some steps to follow in verifying your find.

[Comet Awards and Their Social Impact]
Droves of amateurs probe the depths of the sky every clear, moonless night in search of comets. Most find the lure of glory and prizes irresistible, but for others it's the thrill of the hunt.

[Comets and Light Pollution]
Light pollution has become so pervasive that it compromises the view of the universe for an estimated 90 percent of Americans.

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change
Aug. 30, 2004, 12:12 am (UT)
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rise: 5:10 am
set: 6:50 pm
phase
rise: 7:25 pm
set: 5:09 am
Evening planets

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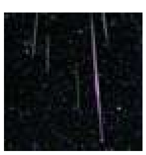
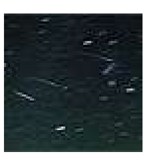
Meteors

Shooting stars, meteors, fireballs, bolides, meteor showers, meteor storms. What's it all about? Find out here.



[Perseids Peak as Predicted](#)
Preliminary analysis of the 2004 Perseid meteor shower confirms the forecast of an unusually brief and intense peak of meteor activity over Europe and Asia.



[Upcoming Meteor Showers](#)
Here are the dates and estimated hourly rates of some of the better showers in 2004 and 2005.

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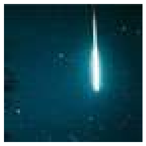
[Orionids in a Dark Sky]

This is a fairly good year for observing the annual Orionid meteor shower, whose maximum generally lasts from around October 20th to 26th.

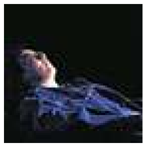
[Meteors: A Primer]

Meteors are visible year-round, but there are nights when you may catch a meteor shower. Here's an introduction to meteors and related topics.



[Basics of Meteor Observing]

Meteor watching is one of the easiest forms of astronomy — here's what to do.



[Advanced Meteor Observing]

Meteor studies have relied heavily on amateur observers for more than a century. They still do. Here are some tips and suggestions on how to plan a meteor watch.

[Meteors That Changed the World]

Meteors and meteorites have left a bigger imprint on human history than is generally realized.

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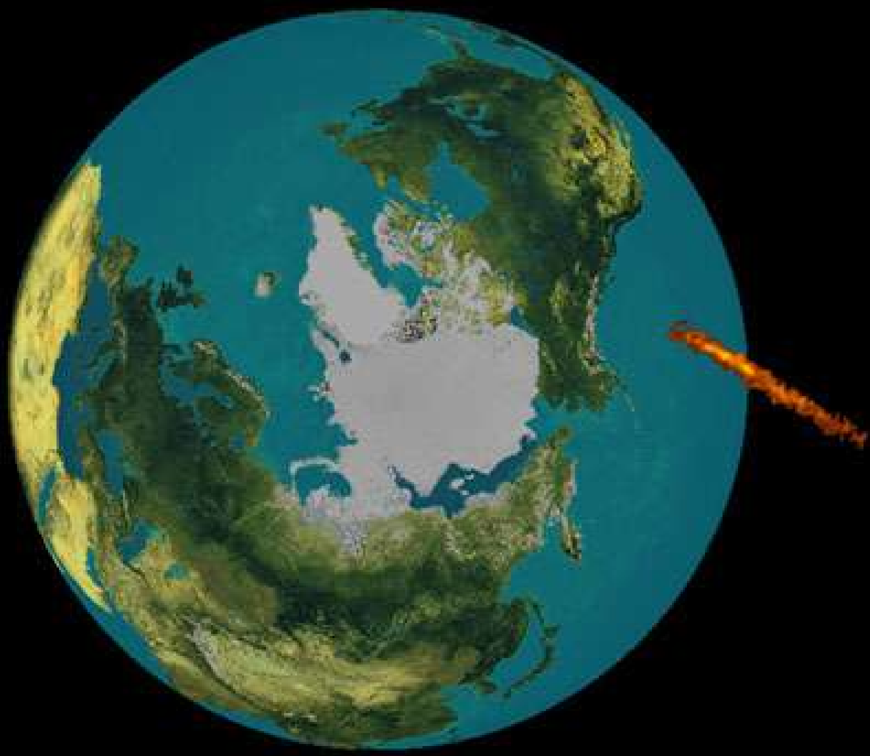
Small Comets

Every few seconds a "snowball" the size of a small house breaks up as it approaches Earth and deposits a large cloud of water vapor in Earth's upper atmosphere.

The University of Iowa



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Last Updated: Tuesday, 02-Sep-03 at 09:22:45 PM

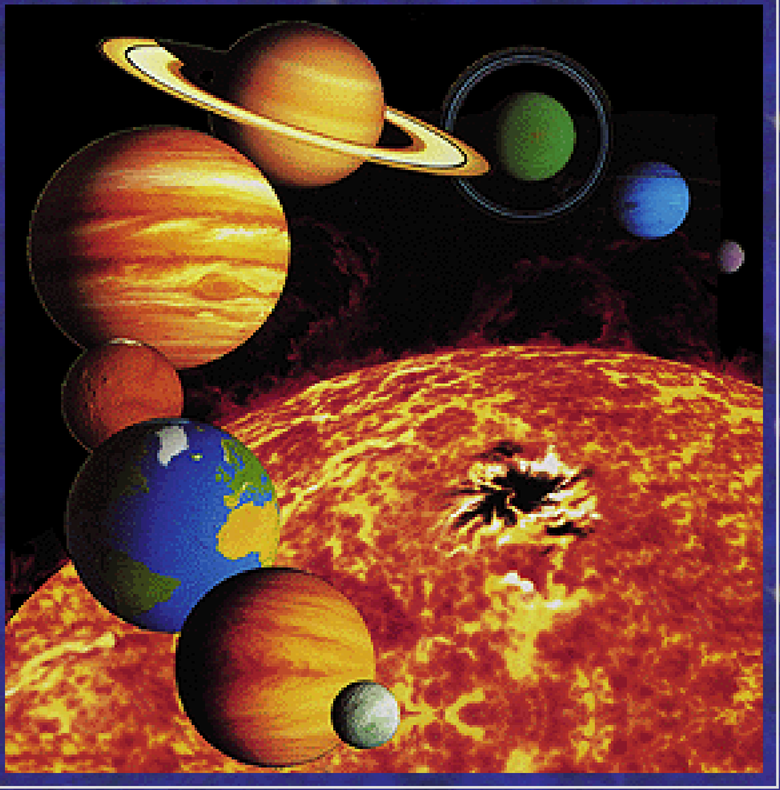
Solar System Collisions

The impact page has moved to
http://janus.astro.umd.edu/astro/impact/
Please update your links!

The Solar System

Listen

What is the solar system? It is our Sun and everything that travels around it. Our solar system is elliptical in shape. That means it is shaped like an egg. The Sun is in the center of the solar system. Our solar system is always in motion. Nine known planets and their moons, along with comets, asteroids, and other space objects orbit the Sun. The Sun is the biggest object in our solar system. It contains more than 99% of the solar system's mass. Astronomers think the solar system is more than 4 billion years old.



The Sun	The Planets
The Moon	The Asteroid Belt
Meteoroids	Comets

Solar System Activities

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NEWS

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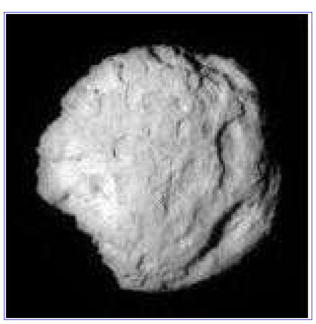
STARDUST REVEALS SURPRISING ANATOMY OF A COMET

Findings from a historic encounter between NASA's Stardust spacecraft and a comet have revealed a much stranger world than previously believed. The comet's rigid surface, dotted with towering pinnacles, plunging craters, steep cliffs, and dozens of jets spewing violently, has surprised scientists. + FULL STORY

Stardust Photos
Stereo Images
Stardust Animations

COMET WILD 2 FLYBY JOURNAL



On January 2, 2004, Stardust flew within 236 kilometers of Comet Wild 2 and captured thousands of particles in its aerogel collector for return on Earth in January 2006. In addition to collecting the samples, which is its primary goal of the mission, the 13,000 miles an hour flyby was quite an event with unexpectedly exciting scientific payoffs. + FULL STORY

DISCOVERY DISPATCH

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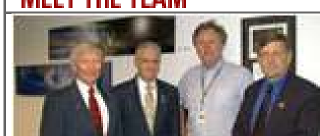
WHERE'S STARDUST ?

STARDUST THEATER

WEBCAM

MEET THE TEAM



SEE WHO'S BEHIND IT ALL

AEROGEL

STARDUST TIMELINE

FEB 07, 1999
LAUNCH

FEB-MAY 2000
1ST INTERSTELLAR DUST COLLECTION

JAN 15, 2001
EARTH GRAVITY ASSIST

APR 18, 2002
APHELION
(NEW DISTANCE RECORD)

AUG-DEC 2002
2ND INTERSTELLAR DUST COLLECTION

NOV 02, 2002
ASTEROID ANNEFRANK FLYBY

JAN 02, 2004
COMET WILD 2 ENCOUNTER

JAN 15, 2006
EARTH RETURN

The The August issue of the Discovery Dispatch is now available.

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ASTEROIDS

Meet the asteroids
What can they do?
Will they obliterate Earth?
How are asteroids found?
Did asteroids deliver life?
What are they made of?
What about comets?
Asteroids in orbit

Coming soon -- the ultimate extinction machines?

4 NOV 1998 Credit the blasted-from-space movies Deep Impact and Armageddon. Or blame the one-day scare from March, 1998, when headlines warned that a beefy asteroid **could** zoom within 30,000 kilometers of Earth -- or even sledgehammer our tender green planet -- in 2028.

Within a day, egg-bespattered astronomers used 1990 data to issue a revised estimate. It's safe to say that the asteroid will miss us by a good 600,000 kilometers -- about twice the distance of the moon.

From the movie "Armageddon". ©1998, Touchstone Pictures.

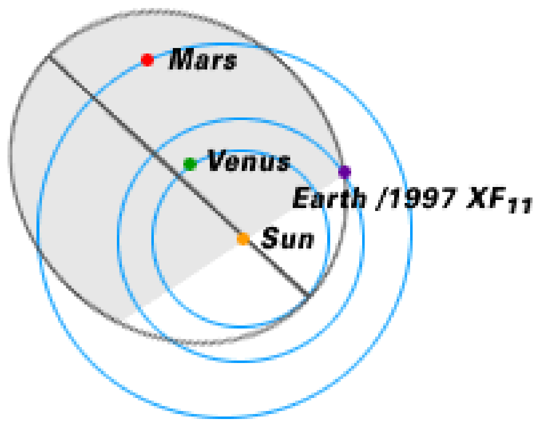
Still, the confluence of events has put The Why Files in an asteroidal frame of mind. Nobody knows the destruction that would result from a collision with one of these sub-planetary objects, but the evidence points to sudden, catastrophic and global damage. You could say it's pretty amazing that 1998 turned out to be a boom year for asteroids. Unlike planets, these misshapen agglomerations of rock and debris are not named for ancient gods. Instead they must answer to clunky handles like "1997 YF11" or "1998 ML14").

Asteroids are also far punier than planets: Ceres, the largest, is about 1,000 kilometers in diameter, but most are under a kilometer across. Most asteroids orbit between Mars and Jupiter, crashing into each other in a silent version of 3-D bumper cars that slowly grinds them to bits.

Puny but potent

Occasionally, an asteroid's orbit becomes more egg-shaped. As the orbit grows more elliptical, it eventually may begin crossing Earth's orbit and become subject to a collision with Earth.

Here's the orbit of the "killer" asteroid 1997 XF11. Once predicted to pass perilously close to Earth in 2028, current estimates give us at least 600,000 kilometers leeway. Courtesy of the Minor Planet Center, Harvard-Smithsonian Center for Astrophysics.



Small bits -- ranging up to maybe pebble size, may become the meteors that brighten our night sky. It's the rarer hunks that are more than 1 kilometer across that spawn doomsday scenarios and Hollywood thrillers.

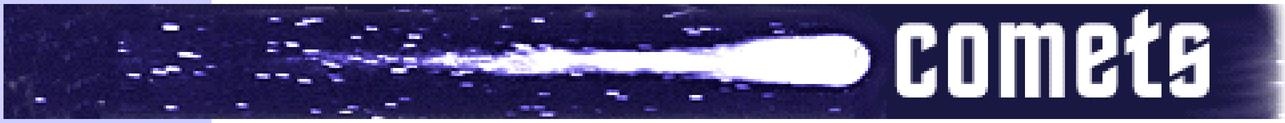
The glare of attention on asteroids has also helped spark a flood of research on the link between asteroids and meteors, on why they leave the asteroid belt, and whether certain asteroids are masquerading as comets.

It's a sure sign of Halloween. So let's squelch the preamble and check out the rocks from the dawn of time. We satisfied our obsession with asteroids with information gathered at the October, 1998, meeting of the American Astronomical Society's Division for Planetary Sciences, conveniently held in Why-Files-ville -- Madison, Wis.

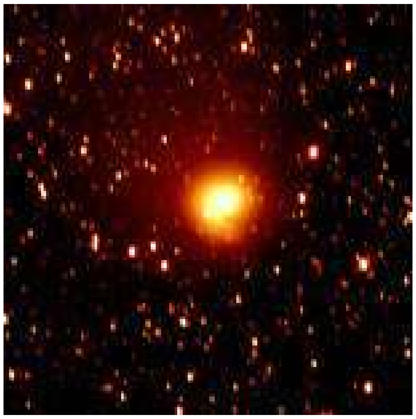
How bad can an **asteroid impact** get?

MORE

The Why Files Staff includes: Terry Devitt, editor; Darrell Schulte, webmaster; David Tenenbaum, feature writer; Susan Trebach, spiritual advisor



Hail Hale-Bopp, bopping through the neighborhood. Comet of the century? Now appearing in a night sky near you.



Comet fiction.

Comet facts.

Do-it-yourself comet!

Extrasolar what?

Where do they come from?

Could a comet crash into the earth?

Are they trying to tell us something?

Are we listening?

more

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Ohio State University Fact Sheet

Community Development

700 Ackerman Road, Suite 235, Columbus, OH 43202-1578

Disposal Of Household Hazardous Materials

CDFS-102

Joe E. Heimlich

One of the most controversial subjects of our time is hazardous waste. Where it goes has been central to many long legal battles. Often, people forget that every household contributes to hazardous waste.

Individually, the waste that is hazardous may seem insignificant, but in the aggregate....Picture, for example, a city of 50,000; if every household contributes an average of five gallons of hazardous material to the solid waste stream each year, there would be over 250,000 gallons of waste each year which would convert to roughly 41 1/3 tons of hazardous waste per year. Whether cleansers, paints, batteries, or motor oil, household hazardous waste should be of grave concern to all citizens.

Each person has options available to them for reducing their dependency on hazardous materials, using less, and careful disposal. This fact sheet will briefly discuss the current "best" means of disposing of household hazardous waste.

Step One: Read the Label

Some hazardous materials indicate proper disposal techniques on their labels. Unfortunately, these are in a minority and some of the containers that do indicate disposal techniques fail to go far enough. If disposal directions are not present on the label of a material known to be hazardous, the label will indicate contents, solubility, or corrosive/reactive potential through the warnings or cautions on the container.

These warnings could include the following:

- "Wear gloves" is a sign of corrosive or dermally toxic substances.
- "Do not store near heat or open flame" suggests ignitability.
- "Do not store near..." indicates reactive qualities of the material.
- "Use only in well ventilated room" is used for toxic fumes and reactive chemicals.

These and similar clues on the label will present a wise consumer with information necessary for proper disposal of the material.

An important note: Even when a container is "empty," it is rarely "empty" of all chemicals. There is some liquid that the pump won't spray and there is nearly always chemical residual on the sides and bottom of the container. Careful attention to disposal is imperative.

Step Two: Use and Reuse as Much as Possible

Often, there's just that "little bit" left over from a job and it does not seem to be enough to bother saving. What to do? **Attempt to use all of any hazardous material.** If you don't need it, perhaps a neighbor might.

Some solvents and cleaners (like paint thinner) can be reused--store the cleaner in a covered jar and when the paint has settled, strain and reuse (see below for the disposal of the sludge).

Some hazardous materials are recyclable; motor oil and fuel oils are often collected by service stations for filtering and reuse. Although the complete use of a product is wise, give leftover products to others only if the material is in its original container with the label intact. Any "precautionary" information that may have accompanied the container should also be given to the new user.

Step Three: Select Disposal Approach

- First and foremost, never burn or dump any hazardous wastes on the ground.
- Do not dispose of any hazardous material "down the sink" unless you are sure it can safely be disposed into the sewer system. "Down the sink" includes letting hazardous materials run down the sewer system (draining an auto's oil into the gutter system or excessive water runoff from a pesticide treated yard) or down the toilet. If you have a septic tank, additional care must be taken.
- Avoid burying any containers or leftover chemicals.
- Do not mix hazardous wastes and do not collect containers and chemicals to dispose of them at one time.
- Solidify any liquid wastes. This involves using an absorbent material (sawdust, kitty litter, paper towels, rags) to soak up a liquid hazardous material. Do not solidify more than one chemical at a time. Using gloves, sweep or dispose of the material into a plastic bag, and then dispose of with other household garbage.
- Use this same process with any "empty" container other than an aerosol container. It is often good to "open" a non- aerosol container with wire cutters or scissors and air-dry; wearing gloves, swab the inside before disposal. Dispose of the rags or paper towels after they have aired outside.
- Latex paint can be solidified by exposing the paint to air. When dried, the paint and container

can be disposed with household refuse. Wrap empty containers in several layers of newspaper prior to disposal. This prevents environmental contamination and reactive potential.

- With aerosol cans, turn the container upside down and depress spray button, with nozzle facing paper toweling, rags or any absorbent surface. When the spray has lost pressure, wrap the can in several layers of newspaper and dispose with household refuse.
- Some cleansers can be poured down a drain. If you have a septic tank, drain disposal should nearly always be avoided. If cleansers are designed to be used with water in a home or in sinks, showers, toilet bowls, and tubs, the material is probably drain disposable. Let the water run, rinse the container and slowly pour the water/chemical down the drain. Allow the water to continue running after the chemical is gone. Allow the container to air dry (or swab with paper towels), wrap in newspaper and dispose in household refuse.
- Antifreeze can be flushed down the toilet if connected to a sewer system.
- Pesticides, herbicides, oil paints, paint cleaners, and oil and transmission fluids should never be flushed into a water system or disposed of on ground or put into household refuse.
- Automobile batteries should never be added to a home's garbage. Some communities have hazardous waste material collection systems for some of these wastes.

In many cases, disposal is difficult at best and the preferred solution is to

1. use an alternative material
2. recycle where possible (oil and batteries) or
3. use the material completely, then solidify residual and dispose of the container as described above.

In our society, hazardous waste is guaranteed. We use many chemicals daily at home, at play, and at work. Wise purchase, use, storage and disposal of necessary chemicals can greatly reduce the negative environmental impact of these chemicals. Finding effective alternatives to their use avoids the creation of hazardous wastes from the home.

Keith L. Smith, Associate Vice President for Ag. Adm. and Director, OSU Extension.

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basel
action
network

turn back
the toxic tide

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Welcome. This is the Internet home of the Basel Action Network (BAN), an international network of activists seeking to prevent the globalization of the toxic chemical crisis.

BAN is based in Seattle, USA and conducts **both domestic (US) and international programs to halt *toxic trade*** -- a ugly form of trade in toxic wastes, toxic products and toxic technologies, that are exported from rich to poorer countries.

At the same time we work proactively in both the United States and around the world, to ensure national self-sufficiency in waste management through ***clean production*** and ***toxics use reductions*** and in support of the principle of ***global environmental justice*** -- where no peoples or environments are disproportionately poisoned and polluted due to the dictates of unbridled market forces and trade.

The name Basel Action Network refers to an international treaty known as the Basel Convention. In 1994, a unique coalition of developing countries, environmental groups and European countries succeeded in achieving within that Convention, the Basel Ban -- a decision to end the most abusive forms of hazardous waste trade. In 1995, the Basel Ban was turned into a proposed amendment which when ratified (see Deposit Box) by the requisite number of Parties will enter into force and will become international law.

Unfortunately, very powerful governments and business organizations are still trying to overturn, circumvent or undermine the full ratification and implementation of the Basel Ban and in general seek to achieve a "free trade" in toxic wastes. The countries and organizations that pose the greatest threat to the Basel Ban are listed in our Hall of Shame. Because the United States is the only developed country in the world that fails to control or prohibit toxic trade and has failed to ratify the Basel Convention, our work in the United States is of paramount importance.

BAN works to counter the regressive efforts of these few countries and to once and for all close the sad chapter of toxic colonialism. We serve as a ***campaigning organization***, an ***investigative and research body***, a ***political advocacy group***, and as the ***definitive clearing house*** for information on toxic trade. In fulfillment of these goals, BAN seeks your activist (Join Us!) and economic support (Support Us).

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Top Story: BAN Files Motion for Summary Judgment to Stop the Export of US owned Ex-warships.

The Pledge: Responsible Electronics Recyclers in North America and where to find them!

The Film: To Order" Exporting Harm" the Video

Article: "Recycling: No Excuse for Environmental Injustice"

Press Release: EPA Guidance on E-waste Denounced as Dumping-as-Usual

Press Release: EPA Blocks Export of Ex-Naval Vessel to China

BAN Report: Mobile Phones are Toxic Waste

BAN Report: BAN Discovers New E-Waste Dumping Ground in China: BAN Report

Deposit Box: See which countries have ratified the Basel Convention's Ban Amendment

Interview: Jim Puckett, BAN coordinator on with National Public Radio

Latest Ratifications: Nigeria, Oman, Hungaryand Bostwana ratify the Basel Ban Amendment ratify

BAN Report: On Basel Convention Conference (COP6)

BAN Report: Export of Harm: The High Tech Trashing of Asia

BAN Report: Export of Harm: The Canadian Story

News: China Responds to "Exporting Harm"

Global Toxics Report Card

The Survey: First ever Survey of CRT Recycling in USA

TOP STORY

BAN and Sierra Club File Motion for Summary Judgement to Halt Bush Administration Toxic Ship Exports

NEW! **FIRST EVER SURVEY of USA CRT RECYCLERS**

Imported Cathode-Ray Tubes in China dumped along the Liangjiang River.
Photo: Copyright Stefan Irvine
from the Sunday Morning Post Story "Ghosts in the Machines"

BAN's Comments on EPA's Proposed Rule on CRTs and Mercury Containing Equipment

Press Release: EPA Guidance For E-waste Denounced as Dumping-as-Usual

Full Critique of EPA Plug-In for E-cycling Guidance

EPA's Guidance Document

Following BAN Tip, EPA Blocks Export of Ex-Naval Vessel to China

End-of-Life Mobile Phones are Hazardous Waste

BAN Report: Mobile Toxic Waste

BAN Discovers New E-Waste Dumping Zone in China

BAN Report: Summary of Findings

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See Reactions to MARAD's Draft Environmental Assessment

BAN/Sierra Club Amend Complaint to Include Action Under the Resource Conservation and Recovery Act

UK WILL ALLOW 4 SHIPS TO BE OVER-WINTERED BUT MUST RETURN TO USA NEXT YEAR!

BAN/Sierra Club Victory Press Release

Earlier UK Environment Agency Press Release

MARAD Press Release

Help Fund our Lawsuit to Stop the Export of Toxic US Ships:

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Report:

Needless Risk

A4 Size, Letter Size

BAN/Sierra Club File Suit to Stop Export of Toxic Naval Ships

Press Release: Judge Grants Partial Restraining Order

READ JUDGE'S INITIAL DECISION

AMENDED LEGAL COMPLAINT (26 November 2003)

DECLARATION OF JIM PUCKETT, COORDINATOR OF BAN

OPINION ARTICLE from THE BALTIMORE SUN

Out

of

the

Closets!

The Electronics Recycler's Pledge of True Stewardship

The World's Most Rigorous
Environmental and Social Justice
Criteria for Recycling E-waste

Where to take that old computer!

The Basel Action Network, a project sponsored by the Asia Pacific Environmental Exchange depends on *your* support to end toxic colonialism. We are the only ones doing this vital work and we exist entirely from tax-deductable charitable grants and donations. If you believe in our efforts please give what you can.

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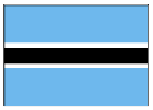
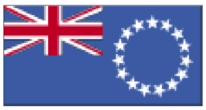
Congratulations Botswana and Cook Islands,:

Latest Ratifications of Basel Ban!



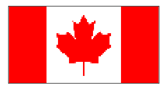


See Deposit Box for Latest Tally

BAN REPORT ON BASEL CONVENTION CONFERENCE (COP6) NOW AVAILABLE

BAN with United Nation Commission Human Rights Special Rapporteur on Toxic Waste, Madame Veseley. COP6, Geneva, December 2002. Copyright BAN

Export of Harm:
The Canadian Story



Action Alert:
Canadians Please Write Your Ministers Now!

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PRESS RELEASE for Report | **PHOTOS FOR PRESS**

China Responds to "Exporting Harm"

New List of Wastes China has Banned for Import, 15 August 2002

China Seizes Banned Waste

China To Crack Down on Waste Imports

BAN Releases Groundbreaking Exposé and Film:

Exporting Harm

Prepared by Basel Action Network (BAN) and Silicon Valley Toxics Coalition (SVT)

February 25, 2002

With Contributions by: Toxics Link India, SCOPE (Pakistan), Greenpeace China

Order The Film

AUDIO: National Public Radio featuring BAN

Acrobat PDF file of Report

Press Release for Report

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Global Toxics Progress Report Card

Country by Country Report on Ratifications of 4 International Toxics Treaties

Last Updated 5 August 2004

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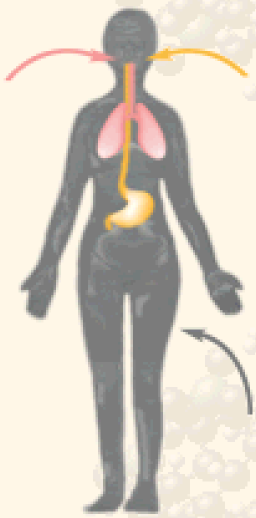
Analyze scientific data to learn how second-hand smoke affects lung development and human health.

PROBLEM SETS & TUTORIALS



Kidneys and Metals Explore the world of renal toxicology, and learn the effect of metals on the kidneys and on kidney cells.

Toxicology Discover ways chemicals can affect human health and develop an understading of fundamental principles of toxicology.

Lung Toxicology Review the basics of lung anatomy and function and learn about toxicology in the lungs, diseases of the lungs, and environmental tobacco smoke.

WWW RESOURCES

The Southwest Environmental Health Sciences Center has supporting materials for the Chemicals and Human Health site and lots of other environmental health activities and curricula.

Hydroville The good citizens of Hydroville need you to help them solve their environmental health problems. A website developed by the Hydroville Curriculum Project at Oregon State University.

Project Greenskate at the University of Washington, is a project that involves students in investigating potential health concerns surrounding the hypothetical development of a city park on a former industrial site contaminated with certain common environmental pollutants.

Arizona Poison and Drug Information Center is a resource for information on natural and human-made poisonous chemicals.

The National Institute of Environmental Health Sciences **:**
Kids' Page has lots of fun activities for kids including games, brainteasers, and current hot topics in environmental health sciences.

Teacher Support has information and curricula for teachers.

The Biology Project
University of Arizona
August 9, 2001
Contact the Development Team

http://www.biology.arizona.edu

= Solstice Homepage =

=Efficiency =

Energy Wise Options for State and Local Governments

2nd Edition

By Michael Totten and Nita Settina
Written with: Jack Gold, Thomas Gray, Katherine Tammaro

Energy Wise Options for State and Local Governments
By Michael Totten and Nita Settina

- Other CPA publications
- Book jacket quotes

January 1993

Center for Policy Alternatives
1875 Connecticut Avenue, N.W., Suite 710
Washington, DC 20009

ISBN: 0-89788-116-8 (Hardcopy price: $15.00)

Hypertext Conversion by CREST,
Comments and questions to:
www-content@solstice.crest.org

URL: http://solstice.crest.org/efficiency/energywise_options/index.html

Annenberg/CPB Learner.org

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INTRODUCTION
SOLID WASTE
HAZARDOUS WASTE
SEWAGE
GLOBAL EFFORTS
THE FUTURE
RELATED RESOURCES

Hazardous Waste

Hazardous waste presents immediate or long-term risks to humans, animals, plants, or the environment. It requires special handling for detoxification or safe disposal. In the U.S., hazardous waste is legally defined as any discarded solid or liquid that

- contains one or more of 39 carcinogenic, mutagenic, or teratogenic compounds at levels that exceed established limits (includingmany solvents, pesticides, and paint strippers);
- catches fire easily (such as gasoline, paints, and solvents);
- is reactive or unstable enough to explode or release toxic fumes (including acids, bases, ammonia, and chlorine bleach); or
- is capable of corroding metal containers such as tanks, drums, and barrels (such as industrial cleaning agents and oven and drain cleaners).

TEST YOUR KNOWLEDGE ABOUT HAZARDOUS WASTE IN YOUR HOME

Who's Responsible?
Businesses such as metal finishers, gas stations, auto repair shops, dry cleaners, and photo developers produce many toxic waste products. These by-products include sulfuric acid, heavy metals found in batteries, and silver-bearing waste, which comes from photo finishers, printers, hospitals, schools, dentists, doctors, and veterinarians. Heavy metals, solvents, and contaminated wastewater result from paint manufacturing. Photo processing also creates organic chemicals, chromium compounds, phosphates, and ammonium compounds. Even cyanide can be a by-product, resulting from electroplating and other surface-treatment processes.

If you think industry is the only source of hazardous waste, you may be surprised. There is hazardous household waste as well. For example, do you use any of the following items?*

automotive products, such as gasoline, antifreeze, and batteries
oil-based paints and thinners
pool chemicals
pesticides, herbicides, and other garden products
household cleaning products

* There are nontoxic alternatives to many of these products that, when disposed of, do not constitute hazardous waste. Check with a local "green consumer" organization or find out more in the related resources section of this exhibit.

[Find Out about Possible Solutions]

Professional Development Workshops
Designed to strengthen the professional credentials of educators at all levels.

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ZERO WASTE is the recycling of all materials back into nature or the marketplace in a manner that protects human health and the environment.

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DISPOSAL & RECYCLING:
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Bans & Imports
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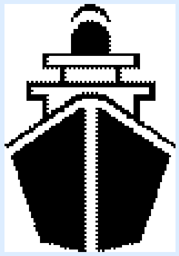
Landfills
Incinerators
Toxics&Wastes
Recycling Issues
Waste&RecyNews
Remediation
CONSUMERS-BUSINESS:
Avoid&Substitute
Recycling
Composting
WaterTreatment
Health Issues



GLOBAL WASTE TRADE

Waste elimination, reduction, and recycling programs are undermined by nations who manage waste by exporting it to other countries. It is particularly alarming to note that some nations who are promoting Zero Waste goals, are also exporting their waste to other countries.

See: SAMPLE LETTER

U.S. FOREIGN WASTE IMPORTS:

Since 1997, the 50 states and Washington, D.C., imported 48 million tons more waste than they exported, according to data in Biocycle managzine, an industry publication. This waste appears to be coming from outside of the United States.

Under U.S. law, there is no general prohibition against the import of hazardous or non-hazardous waste from other countries, or the export of waste to other countries. European countries, Canada, Mexico, and Puerto Rico are some of the countries that export waste to the U.S.

Only hazardous waste is tracked by the EPA. Non-hazardous waste import data is not reported.

TOTALS OF STATE WASTE IMPORTS & EXPORTS:

Year	Waste Imports (tons)	- minus Exports	= Foreign Waste?
1997	21,319,000	- 13,977,000	= 7,342,000
1998	32,837,370	- 14,899,090	= 17,938,280
1999	38,901,100	- 16,090,000	= 22,811,100
Totals	93,057,470	- 44,966,090	= 48,091,380

The annual total "imported" waste by states minus the total "exported" waste by states, appears to be the amount of imported foreign "municipal" waste. This does not include other types of foreign waste imports.

Data source: BIOCYCLE , April 1998, 1999, 2000

Table: ZWA

Only Congressman Paul E. Gillmor (R) from Ohio has offered legislation to stop foreign waste imports. The following proposed legislation addresses the issue of foreign waste imports, but not waste exports: See: LEGISLATION - HR 379 IH (search 'THOMAS' for legislation) / 106th CONGRESS / 1st Session / H. R. 379 / To permit States to prohibit the disposal of solid waste imported from other nations./ IN THE HOUSE OF REPRESENTATIVES / January 19, 1999 / Mr. GILLMOR introduced the following bill; which was referred to the Committee on Commerce.

UNITED STATES

NEWS! **8/18/2000: TOXIC WASTE FROM MEXICO ON THE RISE (source: SolidWaste.com) Toxic waste produced in Mexico by assembly plants along the border (maquiladoras) and shipped to the United States for disposal has increased 300% in the past two years, said environmental protection officials from both nations in a meeting in El Paso, TXon Thursday.**

- **EPA's WASTE IMPORT & EXPORT webpage**
- **Pressure Builds to Export U.S. Nuclear Waste - 1996**
- **U.S. Waste Statistics**
- **BAN - Toxic Trade News:**

  June 9, 1999 - BAN.org - News Release: PLAN TO SHIP ASIAN TOXIC WASTE INTO IDAHO VIA PUGET SOUND DENOUNCED - SEATTLE, USA, -- Environmental groups today denounced a plan to import over 7,000 tons of mercury contaminated toxic waste via the ports of Tacoma or Seattle to a dumpsite in Idaho. The toxic waste produced by Taiwan plastics manufacturer Formosa Plastics Group (FPG) created an international scandal when it was illegally dumped in Cambodia late last year. To date the controversial waste has been rejected by communities in Taiwan, Cambodia, California and Nevada for environmental and health reasons. Environmentalists maintain that the toxic waste should remain in Taiwan to be treated and stored there on FPG company property.

VIDEO: Michael Thomas Productions The Ash Barge Odyssey (Year 2000)--The remaining 3000 tons of Philadelphia's incinerated ash, which was removed from a beach in Gonaives, Haiti where it was dumped 10 years ago, is now holed-up in a hopper barge in the St. Lucie Canal in Stuart, Florida. A 14-year saga still remains unresolved for the people of Haiti, the residents of Florida and the city of Philadelphia.
http://www.michaelthomasprod.com/fla.html

ENVIRO WASTE TRADE ORGANIZATIONS:

- **MUST SEE! BASEL ACTION NETWORK (BAN)** - Works to prevent the globalization of the toxic chemical trade crisis. Address: Basel Action Network Secretariat, c/o Asia Pacific Environmental Exchange, 1827 39th Ave. E., Seattle, Washington 98112 USA / Fax/Phone: 1-206-720-6426 Email: info@ban.org

- **GREENPEACE: TOXIC TRADE CAMPAIGN**
- **TRADE AND ENVIRONMENT DATA BASE (TED)** - American University, Washington DC

Basel Convention **(The United Nations Environment Programme (UNEP)) - "The Convention is the response of the international community to the problems caused by the annual world-wide production ....of wastes, which are hazardous to people or the environment..." United Nations Environment Programme, Geneva**

Origins of the Convention - In the late 1980s, a tightening of environmental regulations in industrialized countries led to a dramatic rise in the cost of hazardous waste disposal. Searching for cheaper ways to get rid of the wastes, "toxic traders" began shipping hazardous waste to developing countries and to Eastern Europe. When this activity was revealed, international outrage led to the drafting and adoption of the Basel Convention.

During its first Decade (1989-1999), the Convention was principally devoted to setting up a framework for controlling the "transboundary" movements of hazardous wastes, that is, the movement of hazardous wastes across international frontiers. It also developed the criteria for "environmentally sound management". A Control System, based on prior written notification, was also put into place.

During The Next Decade (2000-2010), the Convention will build on this framework by emphasizing full implementation and enforcement of treaty commitments. The other area of focus will be the minimization of hazardous waste generation. Recognizing that the long-term solution to the stockpiling of hazardous wastes is a reduction in the generation of those wastes - both in terms of quantity and hazardousness - Ministers meeting in December of 1999 set out guidelines for the Convention's activities during the Next Decade.

SAMPLE LETTER - personal letters are most effective.

SEND (copy & paste) the following letter to your elected representatives:

- **FEDERAL AND STATE GOV'T Links**
- **FEDERAL LEGISLATIVE ADDRESSES AND PHONE NUMBERS:**

  The Honorable (   )
  U.S. Senate
  Washington, D.C. 20510

  (Senate switchboard: (202) 224-3121)

  The Honorable (   )
  U.S. House of Representatives

Washington, D.C. 20515

(House switchboard: (202) 225-3121)

LIST OF U.S. HOUSE AND SENATE ENVIRONMENT COMMITTEES AND SUBCOMMITTEES:

- **U.S. Senate / Members' websites**
  - **Senate Committee on Environment and Public Works**
    - **Subcommittee on Superfund, Waste Control, and Risk Assessment** *
- **U.S. House of Representatives / Members' Websites**
  - **House Committee on Energy and Commerce**
    - **Subcommittee on Health and the Environment** *

(Date)

(Legislator's Name and Address)

Dear (Senator/Congressman) ______________:

Please prohibit the import of foreign waste and export of domestic waste for the purpose of disposal.

Since 1997, the 50 states and Washington, D.C., imported 48 million tons more waste than they exported, according to data in Biocycle managzine, an industry publication. This waste appears to be coming from outside of the United States.

Under U.S. law, there is no general prohibition against the import of hazardous or non-hazardous waste from other countries, or the export of waste to other countries. European countries, Canada, Mexico, and Puerto Rico are some of the countries that export waste to the U.S.

Only hazardous waste is tracked by the EPA. Non-hazardous waste import data is not reported.

In August 2000, Solid Waste Online reported, "Toxic waste produced in Mexico by assembly plants along the border (maquiladoras) and shipped to the United States for disposal has increased 300% in the past two years."

In 1999, U.S. environmental groups stopped a plan to import over 7,000 tons of mercury contaminated toxic waste via the ports of Tacoma or Seattle to a dumpsite in Idaho. The toxic waste produced by Taiwan plastics manufacturer Formosa Plastics Group.

The situation is out-of-control. We need immediate legislative action to stop this outrage. Thank you for your time and attention.

Respectfully yours,

(Signature)
(Name and address)

P.S. For more information, visit www.ZeroWasteAmerica.org

HAZARDOUS WASTE ALTERNATIVES

Glass Cleaner	2 tablespoons of vinegar to 1 quart of water.
Air Freshener	Simmer cinnamon and cloves. Ventilate!
Coffee Cup Stain Removal	Use moist salt.
Handcleaner: Paint/Grease	Baby oil.
Mosquito Repellent	Burn citronella candles, citronella oil.
Drain Cleaner	Plunge, follow with baking soda and vinegar, let sit 15 minutes then pour two quarts of boiling water.
Tile Cleaner	Baking Soda.
Copper Cleaner	Lemon juice and salt.
Spot Remover	Club soda, lemon juice, or salt.
General Cleaner	1 teaspoon liquid soap plus 1 teaspoon borax plus one squeeze of lemon in quart of warm water.
Stainless steel polish	Mineral oil.
Linoleum Floor Cleaner	1 cup white vinegar plus 2 gallons water.
Car Battery Corrosion	Baking soda and water.

Solid Waste Home Page

Hazardous Waste Clean-Up Information

Sunday August 29, 2004

21 Active Users

ITRC Phytotechnologies Classroom Training: September 28-29, New Orleans, Louisiana

The Phytotechnologies training brings regulators to learn, alongside environmental consultants, latest applications of phytotechnologies in remediation and waste management. The curriculum focuses on application and teaches systems design using hands-on team problem solving, case studies, and evening homework. All lecture topics are based on a series of case studies. The instructors, all with abundant field experience, describe advantages of using phytotechnologies plus the technical and regulatory shortcomings of the current understanding. Each day includes a session designed to discuss issues the regulated and regulatory community have experienced or would anticipate in the future. We intend to use the results to reduce or eliminate regulatory issues acting as barriers to safe development of phytotechnologies.

More Information and Registration

View All 3 Items in the CLU-IN Spotlight

Live Web Events (Free!)

>Sep 2: Systematic Approac...
>Sep 14: Phytotechnologies...
>Sep 28: What is Remediatio...

TIP's News Corner

>Courses & Conferences (165)
>FedBizOpps (Aug 16-20)

>Recent Additions
>New Publications
>Technology Innovation News Survey

ToxFAQs"

Frequently Asked Questions About Contaminants Found at Hazardous Waste Sites

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About ToxFAQs"

The ATSDR ToxFAQs" is a series of summaries about hazardous substances developed by the ATSDR Division of Toxicology. Information for this series is excerpted from the ATSDR Toxicological Profiles and Public Health Statements. Each fact sheet serves as a quick and easy to understand guide. Answers are provided to the most frequently asked questions (FAQs) about exposure to hazardous substances found around hazardous waste sites and the effects of exposure on human health.

Each ToxFAQs" is available in both the standard HTML format below or in the PDF format which provides the familiar two page print version widely used at community meetings and distributed via our mailing list. This PDF format requires Adobe Acrobat Reader EXIT, which can be downloaded free from the Adobe web site.

Where can I get more information?

You can get further information on our web site about all the ATSDR Toxicological Profiles and how they are developed. You can also get a longer version of these ToxFAQs" , called the Public Health Statements, from the Public Health Statements home page as well as from each of the ToxFAQs" links below.

What else can ATSDR do?

ATSDR can tell you where to find occupational and environmental health clinics. Specialists in these clinics can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

How do I contact ATSDR?

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333
Phone: 1-888-42-ATSDR (1-888-422-8737)
FAX: (770)-488-4178
Email: ATSDRIC@cdc.gov

A-Z Index of ToxFAQs"

Print Entire List ***87k***

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

- A -

English			Español		
Acetone		*48k*	Acetona		*30k*
Acrolein		*50k*	Acroleína		*27k*
Acrylonitrile		*58k*	Acrilonitrilo		*26k*
Aldrin/Dieldrin		*36k*	Aldrín y al Dieldrín		*30k*
Aluminum		*41k*	Aluminio		*91k*
Americium		*24k*	Americio		*28k*
Ammonia		*25k*	Amoníaco		*27k*
Aniline		*86k*	Anilina		*28k*
Antimony		*47k*	Antimonio		*30k*
Arsenic		*40k*	Arsénico		*30k*
Asbestos		*34k*	Asbesto		*90k*
Atrazine		*85k*	Atrazina		*84k*

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

ATSDR Information Center / ATSDRIC@cdc.gov / 1-888-422-8737

This page was updated on May 25, 2004

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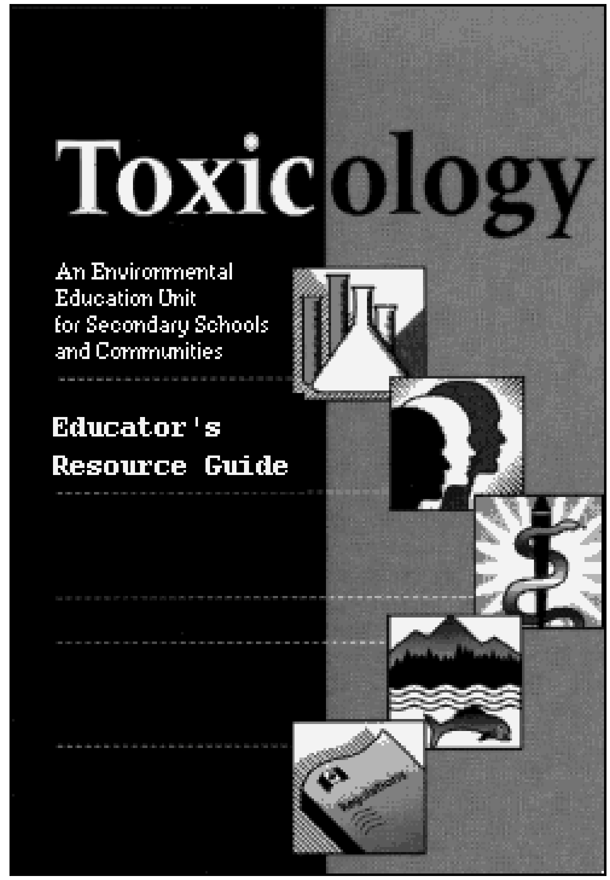
U.S. Department of Health and Human Services

Download the guide in PDF format.

- **English**
- **Français**

For Help with PDF files click here.

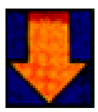


To view the guide on the world wide web, click on any of the links below.

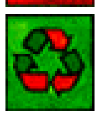
Contact: dwarner@tox.uoguelph.ca
Last modified: July 18, 2001

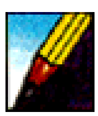
Conclusion

It's far better to reduce the toxicity and amount of solid waste in the first place than to cope with it after it has been created. Through source reduction, recycling, and composting, many environmental benefits and cost savings can be realized. Just remember the four "Rs"...

 **REDUCE** the amount of trash discarded.

 **REUSE** containers and products.

 **RECYCLE** - use recycled materials, and compost.

 **RESPOND** to the solid waste dilemma by reconsidering waste-producing activities and by expressing preferences for less waste.

Test Your Knowledge
Classroom Activities
Health Information
Environmental Careers
Links
Earth Day Info
National Geography Week

Foreword

HAZ-ED
Classroom Activities for Understanding Hazardous Waste

One out of four Americans lives within four miles of a Superfund hazardous waste site. There are Superfund sites and many other hazardous waste sites in every state. Every community generates hazardous waste.

The Federal Superfund Program, administered by the U.S. Environmental Protection Agency (EPA), investigates and cleans up hazardous waste sites throughout the United States. Part of this program is devoted to informing the public and involving them in the . process of cleaning up hazardous waste sites from beginning to end. Haz-Ed was developed to assist EPA's efforts. Haz-Ed assists educators in teaching 7th through 12th grade students about hazardous waste, environmental issues surrounding site cleanup, and the Federal government's Superfund Program.

Haz-Ed can be used as part of a larger curriculum, as special stand-alone activities, or on an occasional basis to teach students about hazardous waste issues. Haz-Ed is a compilation of interdisciplinary activities that focus on the often complicated and sometimes controversial scientific, technical, and policy issues related to hazardous waste sites and Superfund. It is designed to help students develop skills in critical thinking, problem solving, and decision making. It also increases environmental awareness and encourages an environmental ethic in students.

EPA hopes Haz-Ed will be beneficial to you in your efforts to educate your students about the environment and the environmental concerns we all share. If you have any questions concerning Haz-Ed or the Superfund Program, please contact Jean Farrell of Superfund's Community Involvement and Outreach Center, at 703-603-9055.

Acknowledgements

The U.S. Environmental Protection Agency sincerely appreciates the valuable contributions of the following education and environmental professionals to Haz-Ed: Classroom Activities for Understanding Hazardous Waste.

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David Miller
Douglas Reindl
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Helen Waldorf
Debra Weitzel
Midge Yergen

Introduction

Ten million children under the age of 12 live within 4 miles of a Superfund site. The following education materials were developed to focus the attention of 7th through 12th grade students on hazardous waste, environmental issues surrounding hazardous waste sites, and the Federal government's Superfund Program. The units in this package are designed to help students think critically and creatively about hazardous waste pollution problems and some, alternatives for resolving them. The units are interdisciplinary, with a particular focus on classroom interaction and real-world applicability. They are readily usable in schools with a team-teaching or theme approach. The materials are designed for use in a range of subject areas. A table showing the related subject areas for all units is provided at the end of this Introduction for quick reference.

The Haz-Ed materials focus on laws passed by the United States Congress and implemented through regulatory programs directed by Federal agencies, primarily the U.S. Environmental Protection Agency. These are Federal laws and programs that apply to the entire nation. Each state also has a system of environmental laws and state agencies to implement them. Even some local governments have acted to deal with environmental issues through legislation.

although beyond the scope of this document, information about state and local activities can be very useful to you.

Instructional Goals

The units are designed to fulfill four primary instructional goals. Each unit is hands-on and interactive, giving students practice in:

- Collecting, analyzing, and interpreting data in experiments that illustrate the impact of hazardous waste pollution
- Clarifying value systems—their own and those of others—that impact how we perceive and treat the environment
- Analyzing how economics, laws, politics, technology, and other factors contribute to hazardous waste pollution and the process of dealing with it
- Assessing alternatives for resolving hazardous waste pollution problems.

  Students must gain an understanding of the scientific and technical concepts related to the environment, and see that these concepts are useful and applicable in the world. To show the relevance and utility of the concepts and skills underlying these activities beyond the classroom, many of the units challenge students to extrapolate real world applications from the information presented.

What This Package Contains

The package includes 6 **Warm-up Exercises**, 13 **Activities**, and 11 **Fact Flashes**. These units focus on the most important hazardous waste and site cleanup issues in a simple, straightforward style. Many of them can be completed in one class period, but some require two class periods or portions of several classes over a specified period of time. The number of class periods required for each lesson was determined based on an average class period of 45 minutes. These are estimates and are provided only as a guide. The actual time required will depend on the grade level and the skill level of the students in the class.

Pieces can be used alone or in various combinations to accommodate the needs of individual classes and grade levels. Some educators, for example, may choose to conduct several Warm-ups and Activities in sequence over an entire semester. Complementary units are referenced in each Warm-Up and Activity.

Several lessons begin with homework assignments to prepare students for the exercise. Most units call for explanations or presentations by teachers, but several also involve presentations from students and facilitated discussions led by teachers.

Fact Flashes

The **Fact Flashes** are a set of fact sheets that provide the foundation of information on which the Warm-Ups and. Activities are built. The Fact Flashes stand alone and can be used to supplement your lessons in a number of ways.

Warm-Up Exercises

The **Warm-Ups** focus on developing and understanding some basic concepts related to hazardous waste. These exercises are designed to be presented by classroom educators in series or as preparation for related Activities.

Activities

The **Activities** build on the Warm-ups, although they can stand alone. Students examine issues related to hazardous waste and site cleanup. The Activities are designed for presentation by classroom educators. Since some of the Activities take more than one class period, however, educators may wish to consider sharing the delivery with an invited guest, such as an EPA Superfund staff member or an employee of the state government's hazardous waste cleanup program.

Appended Materials

At the end of this document you will find several resources and supplements that can assist you in making the most of Haz-Ed or support your independent activities. The **Glossary** defines many of the terms and concepts students will encounter in the exercises and activities. You may consider providing your students with a copy for their general reference.

A list of abstracted **Suggested Readings** provides both educators and students with additional information. The list is keyed for grade level and provides references to the most relevant exercises and activities.

A list of **Contacts and Resources** provides a variety of information, including key phone 'numbers and Internet addresses.

A brochure, **This Is Superfund**, is a stand-alone document that describes the Superfund Program. It can be used in the classroom and the community.

Finally, the **Bibliography** lists resources used in preparing the Haz-Ed materials.

How To Use This Package

These materials are intended as resources. Educators should feel free to make adjustments in the material to fit in with topics and concepts the class may already be studying or to address topics of particular importance to students in a given geographic area. Also, we encourage educators to use their knowledge of the make-up of the community to add texture to the lessons and reinforce students' in-classroom work. Educators are reminded to consider economic and cultural sensitivities in using the materials that involve living creatures or procuring materials.

How educators and guest presenters deliver these lessons is all-important. Helping students think critically about the world around them and their role in preserving the environment underlies all the materials. Many of the activities involve technical vocabulary and concepts, and instructors may need to spend extra time defining terms and providing background. Accelerated students may not have a problem, but others may. Grade levels listed in the materials are only suggestions; select and adapt these materials to your students' abilities and needs. Feel free to copy these materials and share them with other educators.

Purpose explains what the student will know or be able to do following this activity.

Duration estimates the time needed for the lesson. The actual time required will depend on the grade level and the skill level of the students in the class.

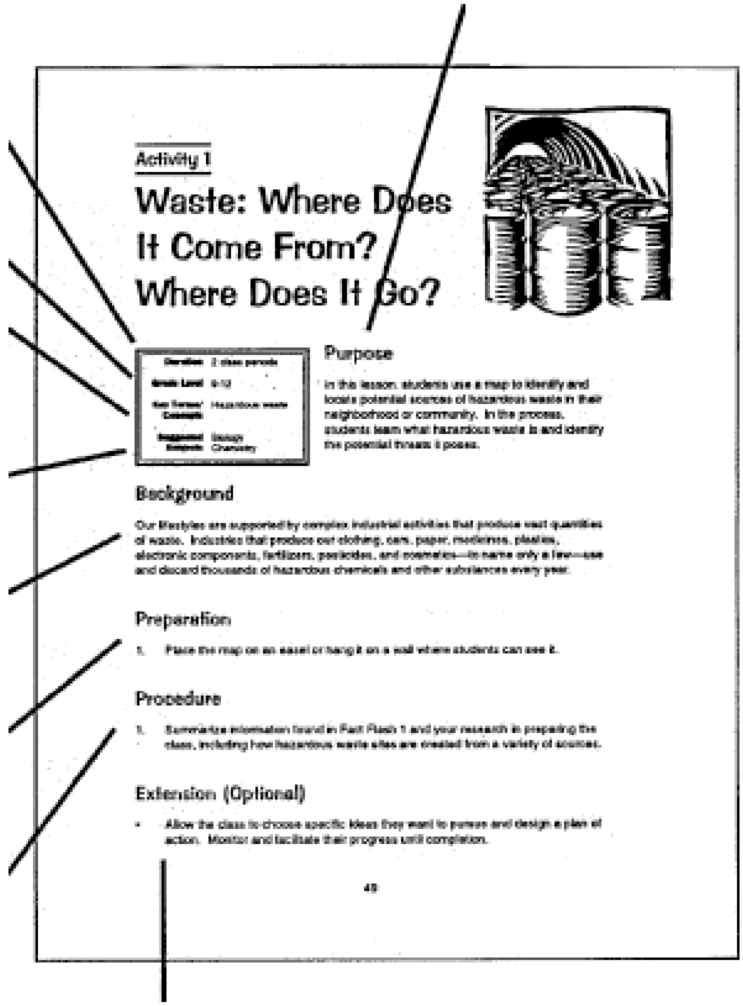
Grade Level indicates the target grade levels for this unit.

Key Terms/Concepts shows terms students will encounter in the unit (defined in the Glossary section of the package).

Suggested Subjects are the scholastic subject areas to which the lesson is related.

Background contains basic facts and context information for the educator's use.

Preparation provides a list of materials and steps the educator should complete prior to class.



Activity 1

Waste: Where Does It Come From? Where Does It Go?

Duration	2 class periods
Grade Level	9-12
Key Terms/Concepts	Hazardous waste
Suggested Subjects	Biology Chemistry

Purpose

In this lesson, students use a map to identify and locate potential sources of hazardous waste in their neighborhood or community. In the process, students learn what hazardous waste is and identify the potential threats it poses.

Background

Our lifestyles are supported by complex industrial activities that produce vast quantities of waste. Industries that produce our clothing, cars, paper, medicines, plastics, electronic components, fertilizers, pesticides, and cosmetics—to name only a few—use and discard thousands of hazardous chemicals and other substances every year.

Preparation

1. Place the map on an easel or hang it on a wall where students can see it.

Procedure

1. Summarize information found in Fact Flash 1 and your research in preparing the class, including how hazardous waste sites are created from a variety of sources.

Extension (Optional)

- Allow the class to choose specific ideas they want to pursue and design a plan of action. Monitor and facilitate their progress until completion.

49

Procedure sets out step-by-step instructions for executing the lesson. Wherever appropriate, this section includes questions the educator should ask or anticipate from the students, student worksheets, and answer keys.

Extension (Optional) offers ideas for carrying the lesson further by suggesting follow-up, extra-credit activities, or ways to expand participation beyond the classroom.

Most units provide questions to stimulate student discussion, but few have a single, “right” answer. These questions are intended to draw on the students’ abilities to identify. various options, Strategies, and reasons in arriving at their answers. Educators can ask students to describe how they arrived at a particular answer and encourage them to compare their answers and approaches with those used by other students to answer the same question. Where there may be several answers to the same question, challenge students to explore why answers are different and how to determine which, if any, are correct. This approach helps students develop critical thinking skills in a stimulating, noncompetitive environment.

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- Spiders Songs & Poems
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- Squirrel Songs & Poems
- A List of Ways to Encourage Good Behaviour
- A List of Tried and True Theme Ideas
- A List of Fundraising Ideas
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Links

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- homeschooling
- illness, diseases, disabilities, disorders, syndromes...

Discussion

Due to difficulties in using external discussion lists, James set up a forum for teachers to discuss ideas and share resources. We hope you find this a useful resource. Alternatively, click on one of the links below to go directly to that general topic area:

- Primary
- Intermediate
- ECE
- French

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This is where you can submit lesson plans and other resources.

If you want to submit a link, try here.

Submit A Resource

Please note: This is a place to ***submit*** your lesson plans, not send us requests. Unfortunately, due to time constraints, we are unable to fill specific requests.

Your name : [ ]

E-mail : [ ]
(will only be used to contact you if a problem arises)

Into which sections do you think your lesson would best fit?

- ☐ English Language Arts
- ☐ Physical Education
- ☐ Math
- ☐ Science
- ☐ Technology Education
- ☐ Personal Planning
- ☐ Social Studies
- ☐ Fine Arts
- ☐ Information
- ☐ Related Ed Issues
- ☐ Special Events
- ☐ Songs and Poems
- ☐ Funtime Games
- ☐ First Nations

Cut and paste your lesson into the form:

Lesson Grade Level(s):

☐ Any ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12

Objective:

Materials:

Procedure:

Resources:

Books, Videos, Internet resources, Software...

Additional Comments, Notes:

Submit Lesson Reset Form

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main page

About Us

CanTeach was created to assist teachers in finding and using resources online. Although this site has resources which all educators will find useful, we have attempted to place emphasis on lesson plans, resources, & links which have a Canadian focus since there is a need for such materials on the web.

The resources are broken up into two categories. There is a section of **Elementary Resources** which consists of lesson plans and resources, as well as a section of annotated **Links**. With your input these sections will grow to reflect the needs of all educators.

The **Links** section does not intentionally reflect any of our views, although we have tried to avoid overtly commercial sites when possible.

CanTeach looks forward to providing educators with a valuable, extensive resources base. We rely on your help to share lesson plans, link suggestions, and other resources which will aid educators around the world. Please use our Submit form to let us know about your resources.

If you want to contact us about the site, please email us. **note that due to time constraints we do not field requests for specific resources.**

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return to main page

Science

- Life Science
- Physical Science
- Earth and Space Science

Constellations

Suggested Grades K-3

Objective Students will examine present constellation patterns as well as create their own.

Materials

- The Glow-In-The-Dark Planetarium Book Annie Ingle, ISBN: 0-679-84367-1, $7.50
- Sticky stars
- Black construction paper
- Flashlight
-  

  Two sample sheets of constellations for handouts. Click for a printable, full-page view. Press the 'back' button on your browser to return to this page.

Method

- Shut off classroom lights and cover/close windows
- Turn on flashlight and read The Glow-In-The-Dark Planetarium Book
- Turn off flashlight when finished each page to "reveal" constellations
- When completed book, turn on lights (obviously!) and hand out examples of constellations
- Get children to copy a few with sticky stars on black construction paper (might need glue for stars to stick properly)
- Ask children to create their own constellations
- Older grades may want to attach a story to their constellation for display

Graphing Constellation

Suggested Grades 3+

Objective Students will practice their graphing skills by following specific coordinates to recreate constellations. This activity will strengthen students' skills of visual perception, observation, and recording, and will give them a visual representation of a few constellations.

Materials

- graph paper
- photocopy of the following graphing coordinates:
  - **Ursa Major:** (M,37); (Q,34); (R,34); (U,33); (W,35); (Z,32); (X,30).
  - **Ursa Minor:** (R,17); (O,18); (N,20); (M,22); (K,22); (L,25); (N,25).
  - **Draco:** (B,33); (C,30); (E,32); (D,34); (B,24); (C,22); (F,24); (G,22); (G,28); (G,30); (I,31); (N,30); (R,27); (U,27).
  - **Cepheus:** (G,6); (E,10); (I,12); (J,8); (O,11).
  - **Cassiopeia:** (L,1); (K,4); (O,4); (S,5); (R,2).
- drawing paper

Method

- Hand out the coordinates to each student and have them transfer them onto graph paper.
- Then have students transfer the constellations on the graphs to drawing paper.
- Extension: Ask students to design their own constellations through graphing coordinates. Share the coordinates with classmates and have them draw the coordinates out.

Additional Resources **Internet Resources**

Star Child

Star Journey

Bradford Robotic Telescope Observatory

The Constellation and Their Stars

Alternative Snowflakes

Suggested Grades K-2

Objective Children will discover how snowflakes in nature are really formed, and recreate this process with paper and glue

Materials

- White paper
- Scissors
- Glue

Method

- Explain that snowflakes are created by water vapours bumping into tiny dust particles, which changes the vapour into an ice-crystal ("sublimation"). This ice crystal then grows by bumping into other vapour molecules. When it becomes heavy enough, it falls to the ground as a snowflake.
- Play "Snowflake Game": Split children into two groups- water vapour and dust particles. Children drift around slowly and quietly, and when they bump into the opposite (w.vapour or dust particle) they join hands. Once this occurs, these pairs drift and the process repeats itself until the whole class is joined to form a snowflake. (Note: I made the mistake of playing this in the classroom- Noisy! and lack of space.)
- Making snowflakes: Children first cut out a circle from white paper (water vapour), then rip and/or cut tiny pieces of paper (dust particles) to be glued onto the circle.
- You may want to have all the snowflakes join to display as one BIG snowflake!

Additional Resources **Books**

Snow, John Bianchi and Frank B. Edwards, Pub. Bungalow Books, 1992, ISBN: 0-921285-09-4, $7.95

Cloud Watching

Suggested Grades 3+

Objective Students will examine, identify, and record cumulus, cumulonimbus, cirrus, and stratus cloud formations.

Materials

- drawing utensils
- drawing paper

Method

- Teach students the names and the characteristics of the various cloud formations.

Cumulus -heaped clouds with flat bases and catle-like tops.

Cumulonimbus -anvil-topped cumulus bringing thunder and rain.

Cirrus -white feathery lines or bands at great height.

Stratus -layer clouds usually smooth and dark.

- Set out a time of the day when the class can go out and do a cloud observation and drawing daily (about 15 minutes).
- During this time ask students to draw, colour in, and try to identify the cloud formations that they see.
- Gather as a class and ask students to share their guesses and their reasons for them.
- As a class make a calculated guess at the type of cloud that was seen the most.
- Eventually each student will have drawings of many variations of these cloud formations.
- **Note:**You may want to include predicting the weather by observing cloud formations.

The Sound of Rain

Suggested Grades K+

Objective Students will cooperate to make the sound of rain.

Method

- Begin by gathering students in a circle (preferably not on carpet) and explaining and practicing how each of the sounds are made. **Wind** is created by rubbing your hands in a circular motion on the floor. **Small rain drops** are made with the fingertips striking the floor softly, then a little harder. Finally comes the **heavy rain**, made by all the fingers on each hand hitting the floor quickly together.
- Place students into three groups (wind, small rain drops, heavy rain). Have each sound group mixed together, rather than in seperate groups.
- Each group is responsible for their sound. Signal to the students when their group should join in (ie. wind first, then small rain drops). Each group should continue to make their sound even after another sound joins in.
- Variation: Divide class into four groups: hand rubbers, one finger clappers, four finger clappers, and thigh clappers.

Weather Around the World

Suggested Grades 5+

Objective Students will learn a few key weather terminology and a variety of climates through examining and recording weather characteristics in a variety of communities around the world.

Materials

- newspapers with daily weather forecasts of cities all over the world OR weather internet sites (see below)
- graph paper
- markers

Method

- Have each student pick a city that they would like to do their weather project on.
- Explain to students the following weather terms:
  - **Humidity**- a measure of the water vapor content of the air, also known as relative humidity.
  - **Temperature**- the degree of hotness or coldness measured bu a thermometer.
  - **Pressure**- the force of the atmoshphere, also known as barometric pressure and is measured in kilopascals.
  - **Visibility**- the distance one can see horizontally.
- Every day (best to do it at the same time of day)students check the newspaper or the internet and record their city's weather, looking specifically for the terms listed above.
- After two weeks of recording, have students graph their results for each weather term.
- Compare them with others in the class. What are some reasons for differences?
- Variation: Pick only a few cities to examine and graph the results on big class graphs (one for each term that you would like to be covered). Pick a different colour for each city and then compare them with eachother.

Additional Resources **Internet Resources**

The Weather Office
Weather data provided by Environment Canada.

Making a Rain Stick

Suggested Grades 2+

Objective Students will make a rain stick which will allow them to recreate and betterh understand the sound of rain in a rainforest.

Materials

Per Rain Stick:

- 1 cardboard tube
- 30 stickpins
- cellophane tape
- 1 cup of rice
- wrapping paper and/or paints to decorate it

Method

- Stick in the pins pins through the cardboard tube in 5 rows with 6 pins in each row.
- Put a strip of tape around each row to hold pins in place.
- Tape one end of the tube shut.
- Pour in the rice.
- Tape the other end of the tube shut.
- Decorate the rain stick by covering it with wrapping paper or paint it.
- To recreate the sound of ran, tip the rain stick slowly.

Additional Resources

Internet Resources

Rainforest Action Network Organization

Rainforest Alliance

Earth Found

The Virtual Rainforest

Measuring Rain With a Rain Catcher

Suggested Grades 6+

Objective Students will make a rain catcher and examine and graph rain levels within one month to calculate the average percipitation at their home.

Materials

- marbles or rocks for bottom of rain catcher
- ruler
- plastic bottle
- scissors
- extra fine point marker
- tape
- water
- graphing paper

Method

- Have students cut the top off the bottle so that the width is the same as the base.
- Tape a ruler on the side of the bottle and using an extra point permanent marker, mark off each centimetre (millimetre if your class can handle it).
- Put some marbles or rocks at the bottom of the bottle (this will prevent the rain catcher from tipping or blowing away). Turn the top upside down and tape it inside the bottle.
- Pour some water into the bottle to the first marking, so that everyone starts at the same level.
- Tell children to place their rain catcher in a not so busy area in their yard at home. Ask them to check their rain catcher every morning. When there is some water in it, record the level and bring it to school. (dump the water out so a new recording can be made the next morning). At school, have the children record their rain level with the day's date on their own graph.
- After a month of recording, add up all of the rain levels and figure out the average precipitation.
- Extension: Compare the average precipitations with those around the world (use the internet or look in climate atlases).

Additional Resources **Internet Resources**

Weather Office

Acid Rain & Plants

Suggested Grades Any

Objective Students will observe and learn about the effects of high acidity on vegetation.

Materials

- grass growing in four seperate trays (plant grass seeds in soil on meat trays or something similar about two weeks in advance)
- distilled or bottled water
- tap water
- a mixture of 1 part weak orange juice and 4 parts water
- a mixture of equal parts of vinegar and water.
- recording sheets

Method

- When grass has grown enough to see that it is in fact grass begin watering each tray with their own type of liquid every day.
  tray 1: distilled or bottled water
  tray 2: tap water
  tray 3: orange juice water
  tray 4: vinegar water
- Every day have students record their observations of each tray by drawing how the grass looks and/or writing key words.
- After noticeable effects have occured have a class discussion on what happened to each tray of grass and why. The tray that was watered with the vinegar water should have fared the worst.
- Then move the discussion to how acid rain is similar to the orange juice and the vinegar water. Discuss what will happen if we let acid rain to continue to form and ways to prevent it from falling on our plants and us.

Where Does the Wind Come From?

Suggested Grades 2+

Objective Students will be introduced to the effects that heat has on creating wind.

Materials

- lamp, with lampshade taken off
- talcum powder
- pencil
- piece of paper
- scissors

Method

Part One

- Turn on the lamp, and let it heat up a bit.
- Sprinkle some talcum powder just above the bulb. What happens? What might be some reasons?
(The heat from the light bulb warms the air around it. As the heat rises, it takes the talcum powder with it. In real life, as the sun heats the air just above it also heat up. This hot air expands and becomes lighter; that's why it rises. Cold air moves in the now warm air's place, and this movement of air is wind.)

Part Two

- Cut a spiral out of the piece of paper
- Carefully balance the spiral on the point of a pencil. Don't make a hole in the spiral.
- Turn on the lamp, and let it heat up a bit.
- Hold the pencil with the spiral just above the bulb. What happens? What are some reasons for this?
(The spiral should spin because of the same reason that the talcum powder rose. The air around the bulb is heated and rises through the spiral, which causes it to spin.)

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Home > Elementary Resources > Science > Earth and Space Science

A Variety of Ways to Make a Windsock

Wire Hangar Windsock

Clip the curved part off of a hangar. Form the remaining wire into a circle. Take tissue paper cut into strips 1 inch by desired length(12-18 inches). Wrap one end of the tissue paper around the wire and glue. Continue all the way around. Depending on how you want to hang them, you can use fishing wire or string and hand from ceiling, etc.

Construction Paper Windsock

Roll a sheet of construction paper into a large tube and staple or glue it. Then glue tissue paper strips to hang off of it.

Paper Bag Windsock

Take a white paper bag and decorated it with markers and crayons. Then, cut a whole in the bottom of the bag. Tied string to each side of the whole in the bottom. They glued crepe paper of many different colors around the rim of the bag.

Tissue Roll Windsock

Cover toilet tissue rolls with construction paper. Then glue strips of crepe paper around one

Air Takes Space

Suggested Grades 2+

Objective This demonstration will show students that air takes space.

Materials

- 3 or 4 pop bottles
- 3 or 4 balloons

Method

- Begin by asking students if a balloon can be blown up inside bottle.
- Have a few students come up, push a deflated balloon into one of the bottles and stretch the open end of the balloon over the bottles mouth (you may need to help).
- Ask each of them to try blowing the balloon up (you may want to have some extra bottles handy as to prevent .
- Once every student has had a try, have a discussion on some reasons why the balloon would not blow up.
- (Air takes up space and that is why the balloon would not blow up.)

Air Takes Space #2

Suggested Grades 2+

Objective This demonstration will show students that air takes space.

Materials

- a glass
- a piece of paper towel
- a sink full of water

Method

- Stuff the piece of paper towel in the bottom of the glass so that it will not fall out when you flip it upside down.
- Ask students whether or not they think you can plunge the glass all they way into the sink of water without getting the paper towel wet?
- Hold the glass upside down and plunge it into the sink.
- Hold the glass under water for about 10 second and then slowly and steadily lift the glass up, making sure not to tilt it at all.
- Pull out the dry piece of paper towel and show it to the students.
- Have a class discussion on some possible reasons of why the piece of paper towel stayed dry.
- (The air filled the glass up and that is why water couldn't get in it.)

Air Takes Space #3

Contributed by Bonnie Fulgham

Suggested Grades 1-3

Objective This demonstration, will show students that air takes space.

Materials

- glass jar
- styrofoam packing peanut
- clear basin of water (glass bowl or aquarium)

Method

- Float the packing peanut on the surface of the water.
- Ask students what will happen if you place the jar upside down over the peanut in the water.
- Place the jar over the peanut and push straight down into the water. The peanut will be pushed to the bottom of the water.
- You can combine this with putting paper toweling in the bottom of the jar as both with show the same thing.
- The air in the jar kept water from entering the jar (toweling stayed dry) and pushed the peanut before it to the bottom of the basin.

Rock Collecting

Suggested Grades 2-4

Objective Students will practice classifying rocks in the categories sedimentary, igneous, and metamorphic.

Materials

- plastic jars that students can easily carry with them
- 4 large pieces of paper per student
- markers
- examples of sedimentary, igneous, and metamorphic rocks (real, pictures in books, and/or pictures from internet: see below)

Method

- Explain to students the major classification system for rocks.
  Sedimentary: Rocks formed by the layering of sediment.
  Igneous Rocks: Rocks produced by the crystallization of molten lava.
  Metamorphic Rocks: Rocks originating from a previously existing rock that is subjected to high temperature (but not enough to melt it) high pressure, and chemicals.
  Show them examples of these rocks.
- Hand out a jar/pail to each student. Ask students to collect as many different types of rocks that they can. (can search outside of school time, or set aside times during school). Give students about two weeks.
- At the end of this time have students bring their collections to school.
- Hand out 4 large pieces of paper to each student and have them label them sedimentary rocks, igneous rocks, metamorphic rocks, and not sure.
- Explain the different categories again and display the examples.
- Ask students to try to categorize all of the rocks that they collected.
- When done, have the class view their classmates' collections and help eachother with the rocks that others were not able to classify.
- Have each student count the number of rocks that they collected in each category. On small pieces of paper, write down the number rocks collected for each category. Tape these labels on the side of the jar.
- Let students keep their jars as permanent collections.
- Extension: Have student use rock classification guidebooks or those on the sites below to identify the names of some of rocks they found.

Additional Resources **Internet Resources**

The Mineral Gallery
Includes pictures of many different rocks and minerals.

Smithsonian Gem and Mineral Collection
Pictures and descriptions of many gems and minerals.

Making Fossils

Suggested Grades K+

Objective Students will better understand how fossils are created by making their own.

Materials

- plaster of paris
- paper plates
- objects to make impressions of (leaves, shells, twigs, grass, flowers, etc.)
- paint (optional)

Method

- Explain to students about fossilization.
  Fossilization: The preservation of the remains or an imprint of a living organism in a geological structure.
- Pour out plaster of paris into the paper plates. (you might want to do this ahead of time).
- Have students pressing items into the plaster of paris and lifting them up right away to make impressions.
- Explain to students that normally, fossils are created when the object decomposes.
- Let plaster dry.
- Paint if you would like. Try using different coloured paint for each impression.
- Variation:Wrap a plaster of paris ball around a small plastic object (eg: toy for birthday bags like dinosaurs, spiders, etc.). Crack the ball carefully and you should see an impression of the object in the plaster.

Metamorphic Rock: Melting Rocks

Suggested Grades K-3

Objective Students will observe and gain a better understading of the metamorphosing power of heat.

Materials

- 2 cups mini-marshmallows
- 1 cup choc chips
- smooth peanut butter
- waxed paper
- hot plate
- mixing bowl
- mixing spoon

Method

- Mix mini-marshmallows and chocolate chips in a bowl. Add just enough peanut butter so so the mixture clumps together.
- Ask each student to grab a handful of the mixture and make a rock.
- Place "rocks" on waxed paper. Explain to students that right now, the rocks resemble sedimentary rocks. The marshmallows and the chocolate chips could be seen as sediments and the peanut butter could be seen as a mineral that sticks the sediments together.
- Place a few of the "rocks" on the pan and heat them over low heat. When the marshmallows melt, give each student a spoonful of the new "rocks".
- Explain to the students that these new rocks resemble metamorphic rock. The sedimentary rock changed its form and structure because of the heat.

Earthquakes

Suggested Grades 4+

Objective

- Students will understand what is an earthquake.
- Students will know which area is an in high risk.
- Students will know what damage the earthquake will cause.
- Students will know the earthquake safety principles.
- Students will practice these strategies and familiarize with them.

Materials

- a computer with internet access

Method

- The teacher will show some life earthquake pictures to the students, and ask them to share their feelings about the earthquake.
- Why do we have an earthquake? What cause an earthquake? The teacher will use a power point to show a material from the web site,"A Child's View of Earthquake Facts and Feelings". Based on children's drawings explain what cause an earthquake.
  -Earthquake ABC
- Fact and fiction: Group students into three small groups, and provide each group a worksheet from the web site. Using this worksheet to let students practice and discuss their knowledge about the earthquake. After sharing the correct answers, the teacher will give some feedback to students and make sure they get a correct idea.
  -FEMA: Earthquakes Facts and Fiction
- How do we know the earthquake? Using the material from the web site presents the knowledge: we can't predict the earthquake. The teacher should explain the reason why the earthquake can't be predicted. Then, the teacher will group students and provide them how to get information from the internet. During this time, using the following questions to guide students to find some information that they might not know. Which area has the highest frequency of earthquake in the world? Which area has the lowest Frequency of earthquake in the world? Which state is in high risk in America?
  -FEMA for Kids: Earthquake Risk States
  -Virtual Times: Recent Earthquakes around the World
  -NEIC: QUD Earthquake Bulletin
- What damage do the earthquakes cause? What is the biggest earthquake in the history?
  -Discovery Online: Earthquakes
  -FEMA: History of Big Earthquakes
- Because the damage caused by the earthquakes is so huge, knowing some survival strategies is very important. Using three real earthquake situations asks students to find solutions. Group students into three groups, and use

problem-solving strategy to ask them to brainstorm how to do some preparation before, during and after the earthquake. Students share their suggestions and the teacher show students the website to see the information from exports. Finally, the teacher will help students to organize some safety principles.
-Astro News: Preparing for an Earthquake
-FEMA: Earthquake Preparedness

- Role-playing: based on stories from newspapers' reports, students will practice their findings about the safety strategies.

Internet Resources Since the websites presented here are mostly American based, here are a few earthquake sites that are Canadian based:

Canadian National Earthquakes Hazard Program

Earthquake Preparedness

Earthquakes in Canada?

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www.CanTeach.ca

Earthquakes

Earthquakes: Facts and Fiction

✗ Fiction: Earthquakes usually happen in the morning.
✓ Fact: Earthquakes happen in both the day and the night. There is no pattern.

✗ Fiction: There is such a thing as "earthquake weather."
✓ Fact: There is no connection between earthquakes and weather. Remember, earthquakes happen deep in the earth, far away from the weather!

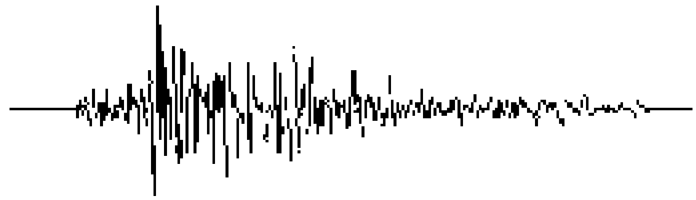
✗ Fiction: Earthquakes are on the increase.
✓ Fact: It may seem like we're having more earthquakes because there are more reporting stations, but the truth is we're not.

✗ Fiction: We can prevent earthquakes from happening.
✓ Fact: No. You can protect yourself by doing things to secure buildings, like your home, but earthquakes can't be prevented -- or predicted.

Information courtesy of the U.S. Geological Survey

EARTHQUAKE

ABC

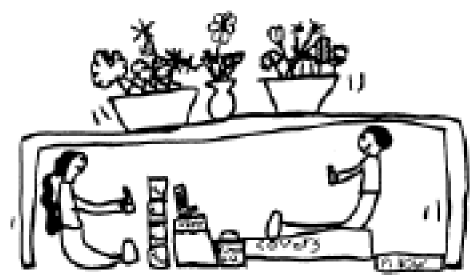


A Child's View of Earthquake Facts and Feelings

With a Parent's Guide to Earthquakes by Dr. Lucy Jones, USGS

Select A Section!

- An Introduction
- The Children's Book
- The Parent's Guide
- Guide for Teachers



(Optimized for Netscape 2.0 or equivalent) Comments Welcome!

Preface

***"An earthquake is the way the Earth relieves its stress by transferring it to the people who live on it."* – on a door at Santa Monica College**

Large earthquakes are a source of stress to all of us who live through them and children are no exception – but to the children of Paula Rao's 2nd and 3rd grade class in Pasadena, California, the Northridge earthquake of January 17, 1994 was the source of more than stress – it was a real-life example of our most recent school project.

Dr. Lucy Jones, a seismologist with the U. S. Geological Survey, is a parent of one of the students in the class and had been coming to give weekly earth science lessons. Our most exciting lesson was when a film crew from the Discovery series of the ABC television network filmed a 2 hour lesson with Dr. Jones that was used in their special program, "Earthquakes: The Terrifying Truth." The big earthquake hit only three days later!

The Northridge earthquake was a special opportunity to live our lessons. Although Dr. Jones's visits were curtailed for the next 2 months, we continued our studies to better understand what we had experienced. When it was time to share what we had learned with our parents, we decided to use an alphabet book format as a way organizing our information. The children generated lists of words they associated with earthquakes and sorted them into three groups: fact words, feeling words, and preparedness words. Each child selected words to illustrate and define. Later the text was typed, pictures were pasted up and a copy was bound for each child to take home. This edition is a copy of that first book.

Copyright information:

Hardcopy Availability!

This book can be purchased from the publisher, Sirius Productions in La Canada. See the Sirius web page for special school pricing and further information.

This is a non-profit effort with royalties going to the San Rafael Elementary school.

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Parent's Guide:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

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A Parent's Guide to Earthquakes

Dr. Lucy Jones, U. S. Geological Survey

Pasadena, CA

As background for the adults who are sharing this book with their children, we are providing a scientist's definition of the technical terms in out Earthquake ABC.

Aftershocks Large earthquakes hardly ever occur alone. When one earthquake happens, we usually see another at a nearby location. To talk about this phenomenon, seismologists coined three terms: “foreshock,” “mainshock,” and “aftershock.” In any cluster of earthquakes, the one with the largest magnitude is called the mainshock; anything before it is called a foreshock and anything after it is called an aftershock.

The fault that moves in the mainshock experiences a great redistribution of the stress on it during the mainshock and it is that disrupted surface that produces most of the aftershocks. Sometimes the change in stress in the mainshock is great enough to trigger aftershocks on nearby faults. However, the stress change dies off quickly with distance from the fault so we rarely see aftershocks more than a few kilometers from the main fault. As a rule of thumb, we say that aftershocks are other earthquakes triggered at a distance from the mainshock fault no greater than the length of that fault.

The length of the fault scales with the magnitude of the mainshock (see Fault) and so do the aftershocks. The aftershock zone of a magnitude 5 mainshock will be under 5 miles across, that of a magnitude 6.5 will be about 20 miles across, while that of magnitude 8 mainshock might be over 200 miles long. Bigger earthquakes have more and larger aftershocks. As the magnitude of the mainshock increases, the magnitude of the largest aftershock, on average, increases as well.

The question is often asked, “How many aftershocks will there be?” On average, for each magnitude 5 aftershock in a sequence, we will see 10 magnitude 4 aftershocks, 100 magnitude 3 aftershocks, 1000 magnitude 2 aftershocks, etc. The relative number of small to large aftershocks does not appear to change with time. In general, an earthquake large enough to cause damage will produce several felt aftershocks within the first hour. The rate of aftershocks dies off quickly with time so even the second day will have many less aftershocks than the first.

We call an earthquake an aftershock as long as the rate at which earthquakes are occurring in that region is greater than the rate we saw before the mainshock. How long that will be depends on the size of the mainshock (bigger earthquakes have a higher rate of aftershocks so it stays above background longer) and how active the region was before the mainshock (if it was quiet, aftershocks stay noticeable longer.)

Children's Pictures:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Parent's Guide:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

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EARTHQUAKE ABC

Guide For Elementary School Teachers

by Paula Rao

This book is appropriate to use with children of all ages. How you share it will depend on the age of the child, the setting, and your personal way of responding to books. You may wish to skip around informally or you may choose to read straight through and return to favorite parts for discussion. This guide suggests possible ways to use the book in a classroom setting. It would be useful to peruse the glossary (A Parent's Guide to Earthquakes) to gain some background before you read the book to the class; then you could add bits of appropriate information when you pause to discuss children's questions or comments. The bullets below indicate questions or challenges you might pose to your students. You will need to decide which are appropriate for the students you teach.

BEFORE YOU READ

- Read or paraphrase the portion of the preface that tells why this book was written.
- Does this book remind you of any projects you've done before?
- What are some words you think of when you hear the word "earthquake"? (Record student responses.)

AFTER THE FIRST READING

- Do you feel any differently about earthquakes after reading this book?
- What surprised you most?
- What question would you like to ask the author/artist of (a chosen page) in this book?

EXPLORING FURTHER

- The children who made this book tried to include science, feeling, and preparedness words. In which group would (your chosen word) be? Can you sort other words into these three categories?
- What do you know about this word that the author didn't say? What else would you write if you were the author of this page?
- Pick an earthquake science word to research and write about.
- Make a model of one of the science words. See Baker: Make it Work! Earth for useful ideas on modeling several concepts in this book. Refer also to "Jello" in the glossary.
- Pick a feeling word to explore through poetry. See Stolz: Storm in the Night for beautiful descriptions of natural forces at work.
- Make a list of preparedness plans that you learned from these pages to share with your

family.

- Make your own drawing for one of these words. (Indicate a page) Do you agree or disagree? Why? How would you rewrite that entry?
- If you chose a topic to make an ABC book about, what would it be?

Your Assignment

How far will you drive?

You are about to drive through a major winter storm. Your mission is to travel safely through the storm. You will rely on weather updates from local radio and your special notebook-computer called *WeatherPad*. Your goals are:

- Stay safe.
- Reach your destination

At the end of your journey, you will be asked to write an essay. You will be asked to defend the decisions you make during your trip! Your "grade" for this exercise will be determined by how your journey ends up and how you could have improved upon your results.

Take a new identity

You will make the trip as someone else! We are about to assign you a new identity. Your objective is to stay safe or get to your destination safely given your newly chosen identity. You will need to make your decisions based on that person's age, experience, destination, and mode of transportation.

You are in command and are responsible for your decisions. Your "grade" for this exercise will be determined by how your journey ends up and how you could have improved upon your results.

Skills

This lesson will challenge you to:

- Analyze information presented to you in several forms.
- Understand winter storm terms and weather information.
- Make good decisions.
- Use your writing skills.

While traveling in a car, we have to make many choices, decisions that help us make a safe trip. There are also consequences for making uninformed or poor decisions.

We are counting on you to stay safe! Don’t let us down!

Next: Sources of Weather Information

- Blizzard Attack Main Page • WeatherEye Expert Main Page •

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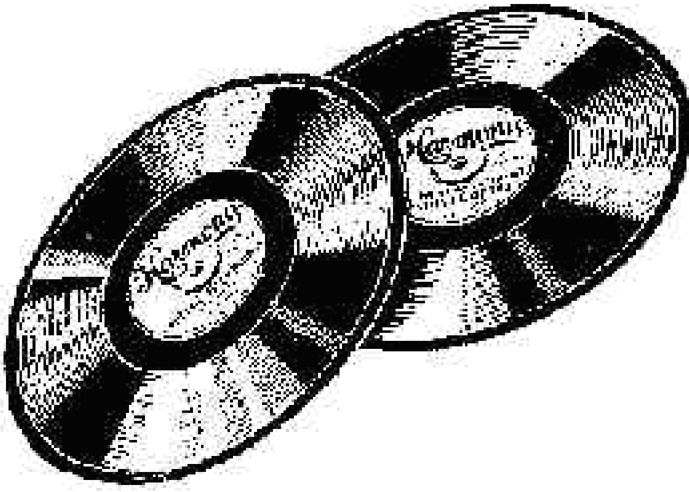
"Blizzard Attack" created and maintained by Meteorologist Roger Evans

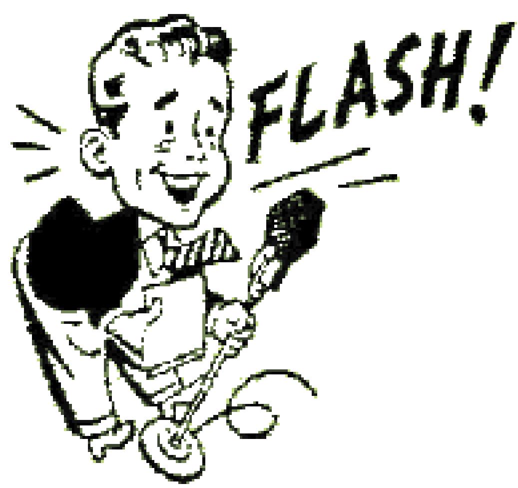


KDUH and WeatherPad

Your sources of travel information

Weather conditions will be changing as you travel through this storm. You will, of course, have to make decisions based on what you see, but you will also have some other information.

KDUH: "Home of Power Rock-and-Roll"
You will get some information from a local radio disc-jockey on your favorite radio station *KDUH*. *KDUH* stands for K- *Dynamite-Ultra-Hype* Rock-and-Roll.



KDUH…."Home of POWER Rock and Roll" has been the station of choice for many years and today is no different. *Dim Bulb* is the jockey of record for the day and night. You expect that Dim and the staff of KDUH will keep you safe during the storm and guide you to your destination.

But to be on the safe side, you have packed the car with your WeatherPad notebook computer for all of the latest information. It is hooked to a cellular phone so you can always get the latest data.

The WeatherPad relays up-to-the-minute weather reports for your area.

You’ll be able to track the conditions of the storm along your trip.

- Are you ready to drive through a winter storm?
- Do you understand winter storms well enough to plan ahead and adjust your plans as you receive more information?
- Can you stay safe from this and all winter storms that threaten your safety?

Next: Meet your "new self."

Blizzard Attack Main Page • Expert Main Page

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Winter Storms

Why are they so dangerous?

Winter storms are dangerous because they produce a variety of life and property threatening conditions! Winter storms vary in duration and severity.

As the picture on the left shows, the scenes we see after most winter storms are often beautiful. During storms, the variety of conditions that are present often times are quite dangerous.

The Dangers of Winter Storms

1. Snow and heavy snow

Snow is dangerous to travelers since it causes the road to become slippery. One of the more dangerous times during winter storms is when the road initially becomes snow covered. A thin layer of snow offers less traction than an inch or more. When traveling during a falling snow, remember to be especially careful when the road is first covered with snow. Snow often leads to other problems which will be described below.

2. Rain or freezing rain

Freezing rain is extremely dangerous to travelers since it coats roadways with ice. This reduces the friction or "grabbing ability" that tires normally need to keep a car attached to the road. When you drive on ice, you are no longer on the road!

3. Sleet and snow pellets

Sleet and snow pellets often occur during major Winter storms when the atmosphere is near freezing on the eastern edge of the storm. Usually this is a sign of a "large and dangerous" storm which will have strong winds and colder weather following.

4. Wind and blowing snow

One of the major dangers of winter storms is wind. Wind transports moisture into the storm at the surface and aloft which allows the storm to intensify and continue unabated.

Wind can also create life-threatening conditions. Wind driven snow can cause "white-out" conditions which reduce visibility so much that motorists can not see the road or other vehicles traveling on the road. White-out conditions occur most often with major storms that produce a drier, more powdery snow.

If you encounter white-out conditions, you should reduce your speed considerably until conditions improve or find a safe place to pull off of the road and remain there until the storm ends. A safe place is one that does not obstruct traffic, like a parking lot of a filling station.

Wind driven snow can also result in drifting snow. Snow drifts can close roads when large enough, but there are other hidden dangers in snow drifts. While driving at normal speeds in a vehicle and suddenly plowing through snowdrift, you may lose control of your vehicle. To avoid this, always reduce your speed enough that you can make it through the snow while not losing control. This is not an easy task to master, even for experienced drivers.

5. Dangerously cold temperatures:

It's a fact of winter that the weather is cold. Add to that Arctic cold during or immediately following a snowstorm and you have a recipe for "life-threatening" conditions. Cold weather and wind combine during the Winter months to "rob our bodies of heat and moisture".

It is important to monitor the conditions at hand during a Winter storm, but even more important to know well ahead of time what to expect once the storm has passed. It is then that the extremely cold weather usually sets into a region! If you become stuck in a Winter storm because the weather is adverse, then you need to know that the weather following it may be just as dangerous.

Blizzards: The worst winter storms
A blizzard is a storm which contains heavy snowfall, strong winds, and cold temperatures. The combination of these elements creates blinding snow with near zero visibility, deep drifts, and life-threatening wind chill values.

Persons should never venture out in blizzards, nor should they continue to travel if a storm is upgraded to a blizzard. You should seek shelter, any safe shelter, immediately. A safe shelter is a public place such as a motel or restaurant if you are on the road, or your home, school, or business if you are already there.

In a blizzard, winds are 35 mph or greater and visibility is reduced to less than 1/4 mile by falling snow and blowing snow.

Next: Hit the Road and Have a Safe Trip

Blizzard Attack Main Page • Expert Main Page

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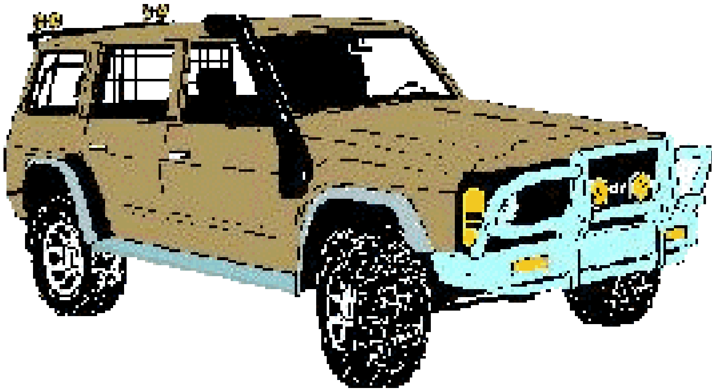

Gas Up and Get Going!

It's 1 p.m. and you're leaving home!

Well, you need to get on the road to make it to Iowa City by 5 p.m. With your truck now full of gas, you head out of Charles City at 1:15 p.m.

So far the weather seems to be holding up quite well, although it has started to snow a little bit. You are really excited about visiting James today for his birthday and as the miles are racked up, the weather doesn't seem to be that big of a deal.

As you continue to day dream about tonight's celebration, you

unconsciously flip on the radio and hit the select button to ***KDUH, Home of Power Rock and Roll!***

Hey, Hey, Rock and Roller's....

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Teachers' Guide!

Blizzard Attack!

I. Grade Level and Time Requirements

- This exercise has been developed for grades 7 through 12.
- Blizzard Attack will take between 1 to 2 hours to complete.
- Blizzard Attack may be done by a single student or in groups.

II. Introduction

This weather exercise has been designed to cover some of the basic skills needed to stay safe during winter storms. The same principles apply to any region of the country.

The lesson takes the form of a fictitious journey between two cities on a day when the weather is expected to be adverse. Students assume an identity, in this case Grandma Brown, who is planning on visiting her grandson for his birthday. Grandma Brown is a real trooper when it comes to life and weather. She is determined to make it to to her destination, regardless of the conditions outside.

As the students live the life of Grandma Brown for their journey, they encounter an increasingly "hostile weather environment" as a winter storm quickly becomes a blizzard over the state. The students are directed to stay safe during their trip and/or reach their destination.

Along the way, they are given updates on the weather from two sources: a radio disc-jockey named Dim Bulb, and from a 21st century notebook computer, called WeatherPad. These two sources of information combined with newly learned knowledge of winter storms, some common sense, and the student's ability to "put themselves in Grandma Brown's shoes" will allow the students an opportunity to explore a mock-storm in the making.

More importantly, it will also develop or extend their ability to think critically during adverse weather situations and understand the risks involved when traveling in the winter months in areas where winter winter can claim lives.

As you follow the story line, you will notice a humorous approach to the characters that make up the **"Blizzard Attack"** education module. This was done for two reasons. First, staring at a computer screen for any length of time can become very dull unless there is something to propel us forward. Thus, humor has been used as this vehicle. Secondly, the target audience made up mostly of students is more likely to respond to this approach, since the lesson exhibits an interactive game-like posture.

The hope of the author is that both adults and students can find it entertaining and informative.

III. Lesson Objectives

After the exercise has been completed, the student should be able to:

- Better understand the dangers of winter storms.

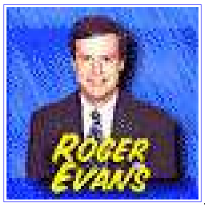
- Better identify current and future hazardous weather conditions based on current weather information that is received.

- Think critically through a weather situation and make intelligent decisions
  based on the reliability of that weather information.

- Better understand the personal responsibility for one's decisions during adverse winter weather and the consequences that may follow.

- Defend his/her choice for continuing or ending the journey at hand with concrete explanations, clear and intelligent writing skills, and proper use of the English language.

Assignment and Grading the Exercise (Teachers' only)



About the Author: Roger Evans is the Chief-Meteorologist at KGAN News Channel 2 in Cedar Rapids, Iowa. He graduated from the University of Wisconsin-Madison with a Master's Degree in Meteorology and has been forecasting weather in eastern Iowa since 1987. If you have questions about this lesson, please feel free to contact Roger Evans

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Glossary of Winter Weather Terms!

Be Prepared for the Upcoming Winter Season!

---

1. **Snow and heavy snow:** If the word snow is heard during a weather forecast or weather report, it means that continuous snow is falling or expected to fall. Heavy snow is used to describe conditions when snowfalls will add up to 6 more inches in a 12 hour period or 8 inches or more in a 24 hour period.

Snow is dangerous to travelers since it causes the road to become slippery. One of the more dangerous times during Winter storms is when the road initially becomes snow covered. A thin layer of snow offers less traction than an inch or more. When traveling during a falling snow, remember to be especially careful when the road is first covered with snow. Snow often leads to other problems which will be described below.

2. **Thundersnow:** Major winter storms sometimes contain "thundersnow". Thundersnow is caused by vigorous clouds within the storm. Similar to thundershowers, thundersnow produces precipitation quickly and in greater amounts. It is common for locations to receive between 2 to 4 inches of snow per hour while thundersnow is occurring.

3. **Rain or freezing rain:** Though rain is more commonly associated with fall and summer storms, large and complex Winter storms often contain a mixture of elements. Depending on where you are in relation to the storm, you may receive rain, freezing rain, or snow. Sometimes you can receive all three from one storm and occasionally one or two types of precipitation may fall at the same time. This can complicate not only the forecast, but how likely it is for travelers to get through the storm!

Freezing rain will occur when the air aloft is warm enough for snow to melt into rain as it falls towards the surface. Once it hits the surface which needs to be below 32 degrees Fahrenheit, it will freeze on contact. Since ice is less dense than water, a half an inch of rain that freezes on contact, will actually lead to more than a half an inch of ice on the ground.

Freezing rain is extremely dangerous to travelers since it coats roadways with ice. This reduces the friction or "grabbing ability" that tires normally need to keep a car attached to the road. When you drive on ice, you are no longer on the road!

4. Sleet and Snow pellets: Sleet and snow pellets form when the atmosphere is near freezing (32 degrees Fahrenheit) at about 5000 feet.

Sleet forms when snow melts near 5000 feet but refreezes before it hits the ground. This forms the common sleet or "ice pellet" that can hit your windows with such force that you often think that someone is throwing sand your way.

Snow pellets or "graupel" are formed when falling snowflakes are *partially melted* as they travel downward toward the ground. Upon close examination, one can usually see the remnants of the parent snowflake that was melted to form the snow pellet.

Sleet and snow pellets often occur during major Winter storms when the atmosphere is near freezing on the eastern edge of the storm. Usually this is a sign of a "large and dangerous" storm which will have strong winds and colder weather following.

5. Wind and blowing snow: One of the major dangers of Winter storms is wind. Wind transports moisture into the storm at the surface and aloft which allows the storm to intensify and continue unabated.

Wind can also create life-threatening conditions. Wind driven snow can cause "white-out" conditions which reduce visibility so much that motorists can not see the road or other vehicles traveling on the road. White-out conditions occur most often with major storms that produce a drier, more powdery snow. If you encounter white-out conditions, you should reduce your speed considerably until conditions improve or find a safe place to pull off of the road and remain there until the storm ends. A *safe place* is one that does not obstruct traffic, like a parking lot of a filling station.

Wind driven snow can also result in drifting snow. Snow drifts can close roads when large enough, but there are other hidden dangers in snow drifts. While driving at normal speeds in a vehicle and suddenly plowing through snowdrift, you may lose control of your vehicle. To avoid this, always reduce your speed enough that you can make it through the snow while not losing control. This is not an easy task to master, even for experienced drivers.

6. Dangerously cold temperatures: It's a fact of Winter that the weather is cold. Add to that Arctic cold during or immediately following a snowstorm and you have a recipe for "life-threatening" conditions. Cold weather and wind combine during the Winter months to "rob our bodies of heat and moisture".

This condition we call *wind chill* which is an attempt to estimate the effects of wind and cold temperatures on the human body. The heat loss that occurs is more pronounced when the wind is faster or the temperature is lower. The longer you are exposed to conditions of extreme cold, the more likely you will fatigue and put yourself in danger of losing your life.

It is important to monitor the conditions at hand during a Winter storm, but even more important to know well ahead of time what to expect once the storm has passed. It is then that the extremely cold weather usually sets into a region! If you become stuck in a Winter storm because the weather is adverse, then you need to know that the weather following it may be just as dangerous.

Common Weather Forecast Terms:

1. **Winter Storm Outlook:** Hazardous Winter weather *may* develop in 2 to 4 days into the future. A "Winter Storm Outlook" is issued when there is a possibility of a dangerous Winter storm 2 to 4 days from the time that the outlook is issued.

2. **Winter Storm Watch:** Hazardous winter weather *may* develop in a few days (one to two days into the future). A "Winter Storm Watch" is issued to provide information to those who need considerable lead time to prepare for winter weather. A "Winter Storm Watch" does not mean that a storm will hit an area, but the likelihood is high enough that people in the watch area should be aware of the possibility of adverse winter weather.

3. **Winter Storm Warning:** Severe weather conditions are imminent or are already occurring. "Winter Storm Warnings" are issued for ice, heavy snow, excessive snow and blowing snow and/or life threatening wind chills.

4. **Winter Weather Advisory:** Winter weather conditions are expected to cause significant inconvenience which may be hazardous. If caution is exercised, the weather conditions present should not lead to life-threatening circumstances. Winter weather advisories may be issued for conditions which include snow, freezing drizzle, blowing snow, and hazardous wind chills.

5. **Blizzard Warning:** The most dangerous type of winter storm. Snow and strong winds are combined which produce a blinding snow with visibility often near "zero". White-out conditions, deep snow drifts, and life threatening wind chills often accompany a blizzard. You should seek refuge from the storm immediately, or not go outside! In a blizzard, winds are 35 mph or greater and visibility reduced to less than 1/4 mile with snow and blowing snow.

6. **Freezing Rain Advisory:** A "Freezing Rain Advisory" is issued when significant icing is expected to occur over a period of hours. Though not always life-threatening, these conditions often lead to property damage in the form of automobile accidents and minor fender benders.

7. **Wind Chill Advisory:** Wind chill values are expected to cold enough to produce frostbite if precautions are not taken. The combined effect of the wind and low air

temperature speed up heat loss from the body. Wind chill values are reported when the temperature is less than 35 degrees and the wind speed is at least 5 mph. Wind chill advisories are issued when wind chill values are expected to reach 35 degrees below zero or less for an extended period of time.

8. **Wind Chill Warning** Wind chill values are expected to cold enough to produce life-threatening conditions. Persons who venture out of doors during a "Wind Chill Warning" may experience frost bite and other cold-related symptoms in a matter of minutes, even if properly clothed for normal Winter conditions. "Wind Chill Warnings" are usually issued when wind chill values are expected to be colder than 50 below zero for an extended period of time.

To return to "Blizzard Attack" at the same place you left to view this page, move the cursor to the "left arrow" located in the upper-left hand corner of the menu bar with icons.

You can also choose "Go"....Back from the menu bar itself.

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Winter Weather Safety Rules!

How to stay safe this winter!

---

1. Dressing for cold weather:

- Wear several layers of loose fitting, lightweight clothing.
- Wear mittens instead of gloves. Wear a hat.
- Remember that entrapped, insulating air, warmed by body heat is the best protection from the cold.

2. Avoid Overexertion:

- The strain from cold temperatures and heavy labor such as shoveling, pushing a car, or walking in deep snow may cause a heart attack in older and less physically fit individuals.

3. Winterize Your Vehicle Early:

- Be prepared against the first blast of winter. Avoid automobile gas line freeze ups by keeping your tank greater than half full at all times.
- Make sure that your car has adequate antifreeze.
- Make sure that your tires have good traction and are inflated to the right pressure.
- Make sure that your heater and defroster work properly.
- Make sure that your battery is not more than 3 years old and that it can carry a full charge.
- Make sure that you have a good ice scraper.

4. Carry a Winter-Survival Safety Kit in your vehicle:

- Bring along blankets and a bright piece of cloth to tie on your antenna if you become stranded.
- Flashlight with spare batteries.
- Extra change of clothing to keep dry.

- Non-perishable foods such as candy bars, canned goods, or high calorie food like Power Bars.
- A can and waterproof matches (used to melt snow for drinking water).
- A compass, shovel and sand, tow rope, and jumper cables.

5. Before traveling:

- Check the latest forecast from KGAN. at KGAN Current Weather!
- Check the latest road conditions before you head out into Winter weather.
- Let someone know where you are going and when you think you will reach your destination.

6. If you become stranded in your vehicle during a Winter storm:

- Stay in your car, truck, or minivan.
- Run the engine at 10 minute intervals for heat.
- Maintain proper ventilation by making sure the exhaust pipe is not plugged.
- Leave the windows open slightly to avoid carbon monoxide poisoning.
- Make yourself visible to rescuers. Tie a bright cloth to your antenna or door handle.
- Turn on the dome light at night, but only when running the engine.

7. At home, do the following before Winter becomes a reality:

- Have your furnace checked before you need to use it.
- Seal any windows that you suspect allow cold air into the house with caulking or plastic.
- Include a home safety kit that includes extra non-perishable food, medicine, and a battery operated radio.
- Keep a flashlight and extra batteries handy.
- Keep candles and matches handy for extended periods of electrical loss.

8. If you lose heat in your home:

- Seal off any unused rooms by stuffing towels or rags in the cracks under the door.
- Cover the windows with blankets or sheets at night if you have some extras available.
- Use only devices that are designed for heating indoors during as emergency heat source and handle all safety precautions.

9. Install and test smoke alarms in your home:

- Have fire extinguishers checked to combat an accidental fire due to the use of alternative heat sources.

Feel free to **print this out** and keep it handy all winter long!

To return to your current position in "Blizzard Attack", go to the menu bar and either choose the back arrow located in the far upper left hand corner of the browser window, or click on the "GO" menu and choose "Back".

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Expert section

- Welcome!
- Lessons
- Current Weather
- Explore
- Photo Gallery

This section is designed for students in grades 6 to 12.

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Professional information for agricultural, small business and commercial customers.

KCCI SchoolNet
Real-time weather data from schools throughout Central Iowa.

KGAN WeatherEye
A weather education site for students, teachers, and parents, complete with lesson plans and quizes.

Louie the Lightning Bug
Part of the Electric Universe that focuses on Electrical Safety for kids.

Managing Energy Costs
Learn how to save on your energy bill.

The Electric Universe
The Electric Universe is a safety and educational site with sections designed for students, educators and parents.

The preceding educational and informational sites are sponsored by Central Iowa Power Cooperative (CIPCO), in conjunction with the following member cooperatives: Clarke Electric Cooperative, Inc.; Consumers Energy; East-Central Iowa Rural Electric Cooperative; Eastern Iowa Light & Power Cooperative; Farmers Electric Cooperative, Inc; Guthrie County Rural Electric Cooperative Association; Linn County Rural Electric Cooperative; Maquoketa Valley Electric Cooperative; Midland Power Cooperative; Pella Cooperative Electric Association; Rideta Electric Cooperative, Inc.; South Iowa Municipal Electric Cooperative Association; Southwestern Iowa Service Cooperative; and T.I.P. Rural Electric Cooperative.

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The CIPCO Advocate | Safety & Education | Weather | Annual Report | Contact CIPCO | Links

A Touchstone Energy® Cooperative

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Welcome To CIPCO

Welcome to Central Iowa Power Cooperative's (CIPCO) web site. We encourage you to explore the various areas of the site to learn more about CIPCO's commitment to service, product value, and resource development. CIPCO is active in the growth and development of the communities it serves.

CIPCO RECEIVES $101.6 MILLION FEDERAL LOAN GUARANTEE

Central Iowa Power Cooperative received approval of a federal loan guarantee through the U.S. Department of Agriculture (USDA) Rural Development's utilities program in the amount of $101.6 million to finance an ownership interest in the new Council Bluffs #4 (CB#4) electric generation plant. The loan guarantee will allow CIPCO to borrow money to secure long-term debt from the Federal Financing Bank at interest rates slightly above the federal treasury rate.

"This investment in new generation represents the first major addition to our generation portfolio since the early 80's. Council Bluffs #4 will help us ensure the availability of capacity and energy to serve our member systems," said Dennis Murdock, CEO of CIPCO.

CIPCO's ownership share of CB #4 will equal 8%. The new unit is a 790 megawatt coal-fired generating plant that will be fueled with low-sulfur Western coal and will be equipped with the latest environmental controls. Not only will CB #4 generate clean energy, it also promises to provide reliability of supply and price stability and will support our continued initiatives of economic development. Construction began in September 2003 and the plant is scheduled to be operational in May 2007.

Central Iowa Power Cooperative is a consumer-owned, not-for-profit cooperative that generates and transmits power to its 13 member systems. CIPCO is headquartered in Cedar Rapids, Iowa and serves 260,000 Iowans in 58 of the 99 counties through our member systems.

In addition to the Council Bluffs investment in new generation, CIPCO is committed to other investments and upgrades to the existing generation fleet, additions to its transmission plant and reconstruction of the older portions of its transmission network. It is expected that these capital additions will nearly double our existing investments in utility plant assets by 2014.

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University of Illinois at Urbana-Champaign
Department of Atmospheric Sciences

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Welcome!

Welcome to the Department of Atmospheric Sciences web page. Here you can find information about the department and its projects. Below you will find news to keep you abreast of changes and events within the department.

Questions/Comments

WW2010 Helper Section Index

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Please wait for entire page to load before clicking

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N

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P

Q

no words starting with this letter

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X

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About WW2010

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

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April 19th Tornado Outbreak

contributors to case study development

Below is a list of those who contributed to the development of the April 19th Tornado Outbreak case study in the WW2010 Case Study Archive. We greatly appreciate the efforts of those who contributed to the development of this case study.

WW2010 Personnel:

Steven E. Hall - Developer and Content Editor - Developed original-version of this online case study. Responsible for new layout, organization, cross linking of helper pages and construction of animations. Implemented text and graphics modifications as recommended by the Content Reviewers.

Bruce Lee - Content Reviewer - Edited module text and diagrams for scientific accuracy. Also provided narrative text for images captured from the chase.

Brian Jewett - Data Management - Collected and archived all weather data that is accessible from this case study.

Selected Images and Photographs:

For resources not developed by the University of Illinois, DAS/UIUC has been granted permission to display these resources for educational purposes only, on a non-profit basis. Images may be viewed directly from the CD-ROM or the WW2010 web site (http://ww2010.atmos.uiuc.edu/). Credit is given to the resource owner in attached captions. Copyright is wholly retained by the owner. Please contact the copyright owners directly for any situation involving the use of images outside of the web server and this CD-ROM. We would like to thank the following for permission to use their photographs and images in the WW2010 web server.

Video footage and stills from storm chase:

Tom Grzelak, Tim Shy, Brian Jewett, Gwen Jewett, and Bruce Lee.

Damage photographs from Ogden, IL:

Norene McGhiey - mcghiey@atmos.uiuc.edu

Storm Interceptor Team Members:

Bruce Lee - Team Leader

Brian Jewett - Team Leader

Gwen Jewett

Tim Shy
Tom Grzelak

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Current Weather

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- user guide

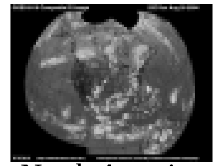
User Interface

graphics text

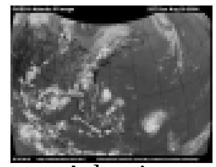
Infrared | Enhanced Infrared | Visible | Water Vapor | Composites |

Infrared Imagery

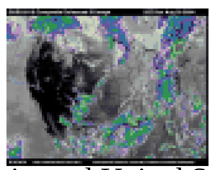

Continental United States

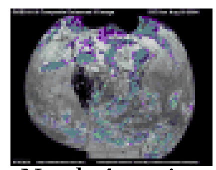

North America

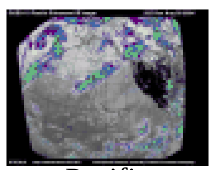

Pacific


Atlantic

Enhanced Infrared Imagery


Continental United States


North America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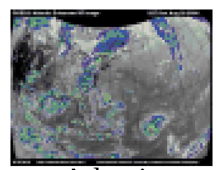
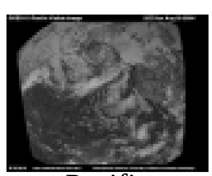

Atlantic

Visible Imagery


Continental United States


North America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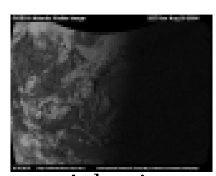
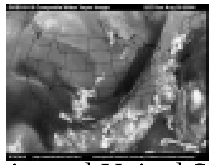
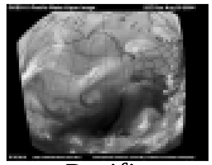
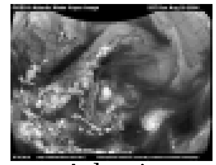

Atlantic

Water Vapor Imagery

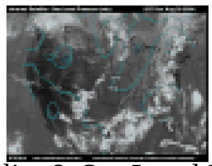

Continental United States

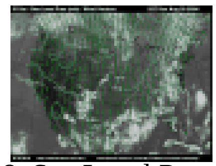

North America


Pacific


Atlantic

Composite Images


IR Satellite & Sea Level Pressure


IR Satellite & Sea Level Pressure & Wind Vectors

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surface

Terms for using data resources. CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

radar

NEW! Online ordering is now available!

The Weather World 2010 CD-ROM's are back!!!
If you would like to learn more about the CD-ROM, please read below. If you would like to order, either click here to order online by credit card or click here for a printable order form.

The Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) would like to announce the release of the 2nd edition of the Weather World 2010 (WW2010) Educational CD-ROM. This resource is being constructed to provide local access to the high-graphics version our entire collection of Internet-based educational resources developed through our participation in NSF's Collaborative Visualization Project (CoVis). Most of these resources are currently available in the Online Guides.

New to the 2nd Edition of the WW2010 CD-ROM:
As seen on the web

- A Completely new Hurricane instructional module filled with new graphics and movies.
- New Modeling section to the Severe Storms instructional module including movies, animations, research results, and online access to streaming video.
- New pages in the Forces and Winds instructional module.
- Updates to the Satellite and Light & Optics instructional modules.

- New pages describing WW2010 Current weather products.
- Plus many other updates and revisions to other instructional modules and background pages.

Features of the CD-ROM will include:

INSTRUCTIONAL MODULES - that use multimedia and the flexible nature of the web to enhance the impact of educational resources. These modules introduce and explain fundamental topics in Meteorology (Pressure, Severe Storms, El Niño, Forecasting etc.), Remote Sensing (Radars and Satellites) and how some of these aspects fit into the Hydrologic Cycle.
NOTE: The only resources found online and not on the CD-ROM are the Tropical Cyclone tracker and 3-D VRML Hurricane. They will still be accessible online from the CD-ROM.

ARCHIVED WEATHER DATA - and case studies of memorable weather events like Hurricane Andrew, Storm of the Century and the April 19, 1996 Illinois Tornado Outbreak. Each case contains relevant weather images, storm histories, photographs and eye-witness accounts.

STUDENT PROJECTS & ACTIVITIES - (complete with answer keys) that provide teachers with a meaningful way of integrating the data and instructional resources into the classroom.

REAL-TIME WEATHER DATA - will also be accessible from selected pages of the CD-ROM to allow the user to apply what they've learned to current weather conditions. These pages will link to relevant weather products accessible through our WW2010 web server.

EFFICIENT NAVIGATION - that allows users to move between hundreds of pages with only a few clicks and return easily.

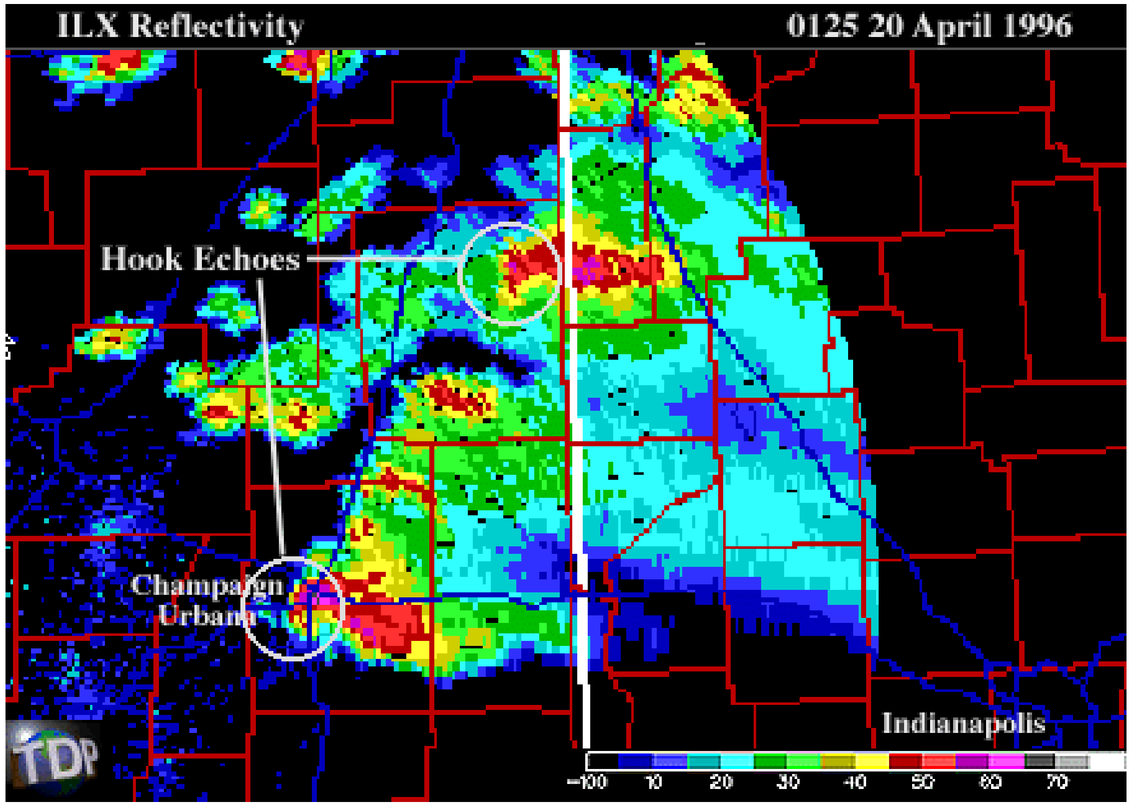
These resources will be accessible from the CD-ROM by using any standard web browser and the interface will be nearly identical to their online counterparts. Therefore the same CD-ROM can be used on a Macintosh or an PC.

Click here to order online with a credit card or for other payment options using a printable order form, click here!

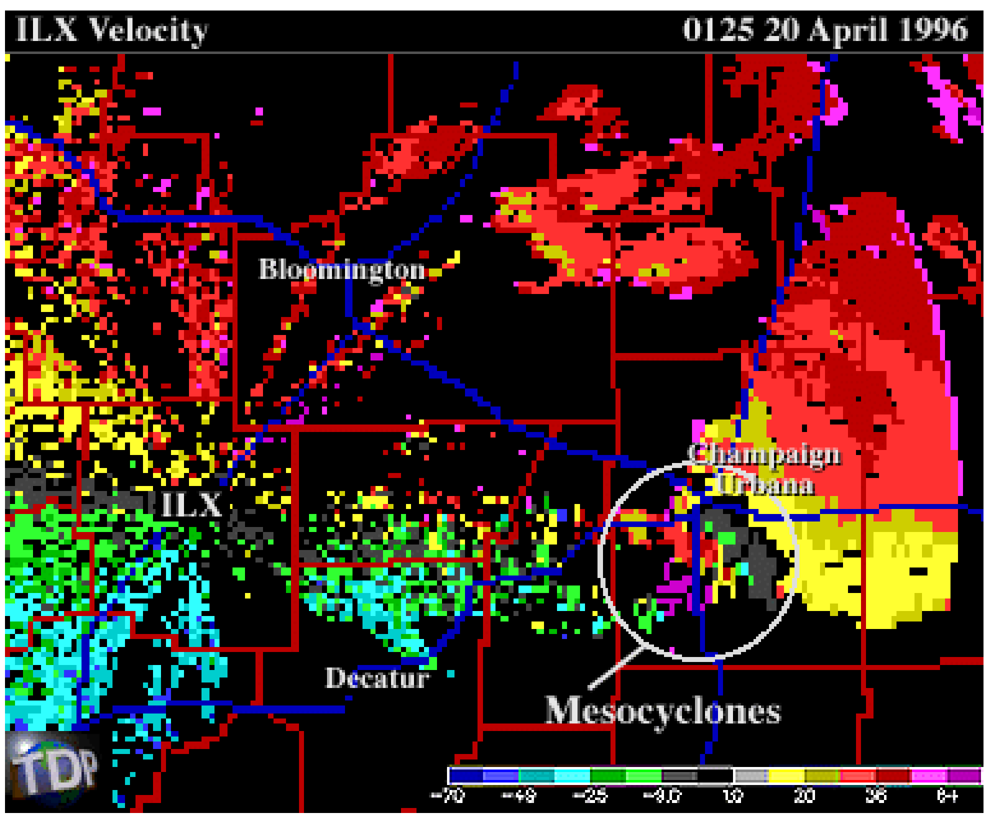
If you have any questions or comments, please contact us at
ww2010@atmos.uiuc.edu

Urbana, Illinois Tornado

nexrad close-ups



8:24pm CDT (4/19/96) - The Champaign sirens had been activated. The ILX reflectivity panel at the time indicated a pair of hook echoes attached to supercells moving through East-Central Illinois.



Multiple mesocyclones were passing through the Champaign/Urbana area.

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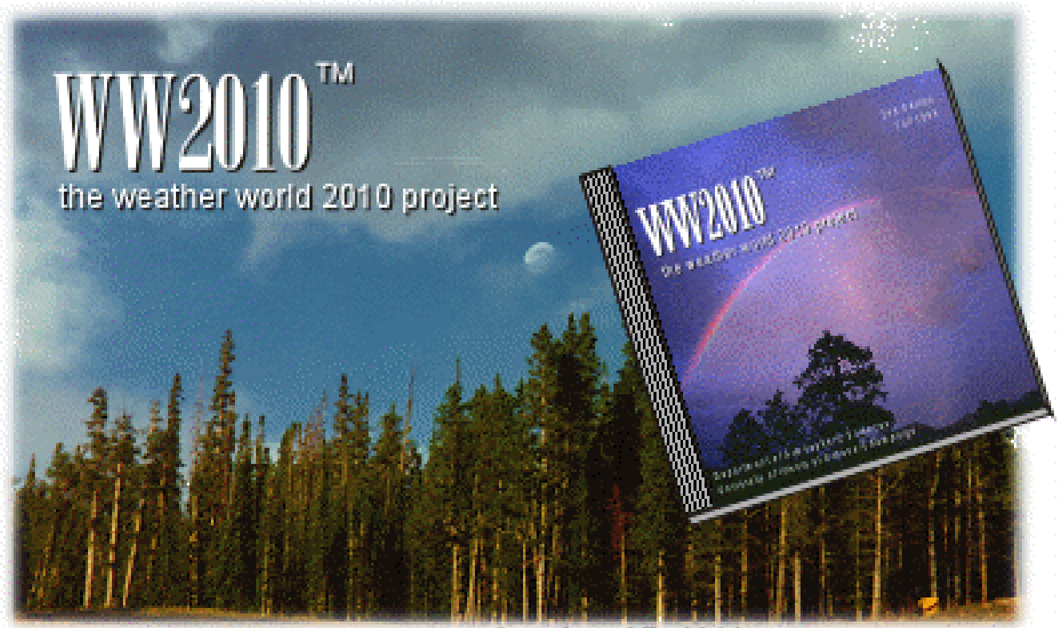
User Interface

graphics text

> To navigate this site , click on the menu items above. The current page is highlighted in yellow.

> Low graphics version of this server is accessible by clicking the "text" option in the blue User Interface menu (above).



October 25, 1999
Multimedia Educational CD-ROM

Go to our popular current weather products section. Just select 'current weather' from the menubar at left from any page to access them.

Our multimedia educational CD-ROM is **now available**.

Popular Features:

- Hurricanes
- Clouds and Precipitation
- El Niño

Developed by the Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC), WW2010 (the weather world 2010 project) is a WWW framework for integrating current and archived weather data with multimedia instructional resources using new and innovative technologies.

To ensure the greatest possible accuracy of our instructional resources, all materials have been reviewed and edited by professors and scientists from the Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) and the Illinois State Water Survey.

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WW2010
09/02/99

Online Guides
Collection of multimedia instructional modules in meteorology and remote sensing, plus curriculum projects and classroom activities.

Archives
Data and descriptions for memorable weather events.

WW2010 Educational CD-ROM
Details and ordering information about our hybrid multimedia educational CD-ROM.

About WW2010
Details about the features, philosophies and personnel responsible for WW2010.

Current Weather
Contains current weather information for the surface, upper air, as well as satellite products.

This is a work-in-progress, so we will release sections as they are completed. To access a low graphics version of this server, click the "text" option in the blue User Interface menu (left).

This web server is a result of cooperation amongst personnel in the Department of Atmospheric Sciences at the University of Illinois at Urbana-Champaign, the Collaborative Visualization Project (CoVis), the Horizon Project, and NCSA. The Collaborative Visualization Project was funded by the National Science Foundation under NSF grant RED-9454729, while the Horizon project was funded by NASA CAN Project Test Applications and Digital Library Technologies in Support of Public Access to Earth and Space Science Data, Grant Number NCC-5-106.

Online Guides

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- remote sensing
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- projects, activities

Projects, Activities
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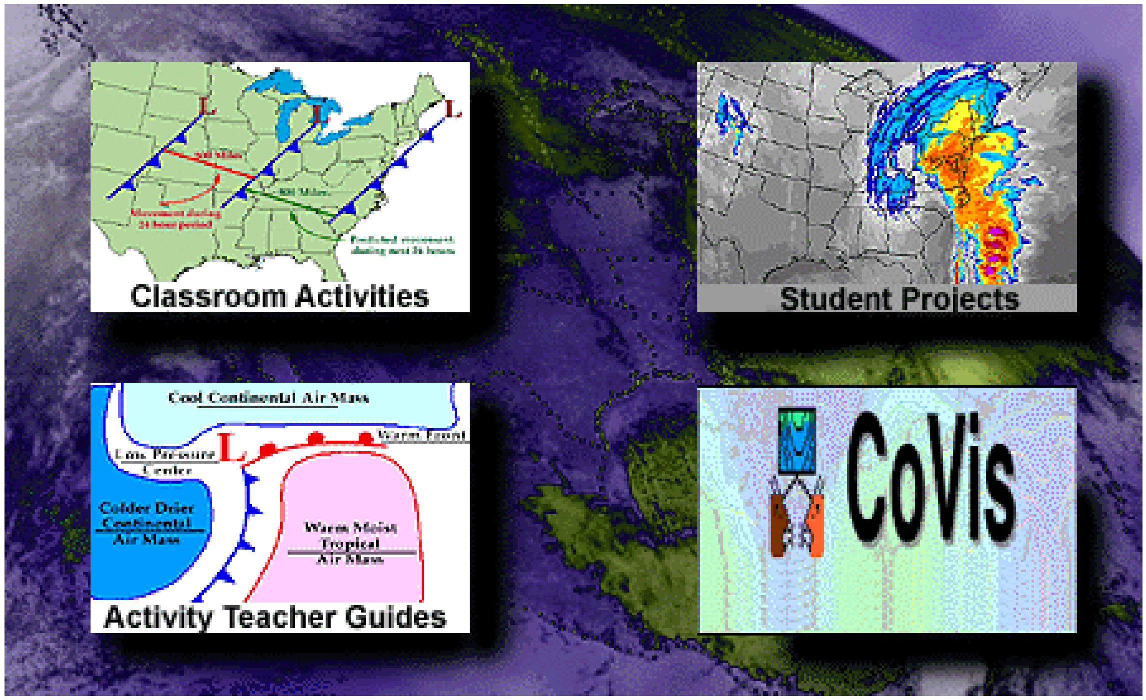
- classroom activities
- teacher guides

User Interface
- graphics
- text



Welcome to the first collection of CoVis-WW2010 student projects and activities in the atmospheric sciences. These resources were developed through our participation in NSF's Collaborative Visualization (CoVis) project which supports project-based learning of the sciences for grade levels 9-12. These resources have already been implemented in a number of CoVis classrooms and have been modified based upon student and teacher feedback. The Projects and Activities have been organized into the following secitions.

Activities

Last Update: 08/01/97

Open-Ended Projects

Two units: case study of a winter storm and learning how to forecast.

Classroom Activities

Short, structured activities on a variety of topics in meteorology.

Teacher Guides

Assessment tools for teachers.

The materials have been broken down into four primary groups. Open-Ended Projects involve working with real-time and archived weather data to solve a specific problem. Classroom Activities provide a structured environment for learning about a variety of topics in meteorology. These activities may require up to 90 minutes of classtime to complete. Teacher guides for each activity have also been provided.

The navigation menu (left) for this module is called "Online Curriculum" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Units of Temperature

from fahrenheit to celsius to kelvin and back

Degrees **Fahrenheit**, (developed in the early 1700's by G. Daniel Fahrenheit), are used to record surface temperature measurements by meteorologists in the United States. However, since most of the rest of the world uses degrees **Celsius** (developed in the 18th Century), it is important to be able to convert from units of degrees Fahrenheit to degrees Celsius:

Fahrenheit to Celsius:

$$^{\circ}C = (^{\circ}F - 32) / 1.8$$

Kelvin is another unit of temperature that is very handy for many scientific calculations, since it begins at **absolute zero**, meaning it has no negative numbers. (Note...the word "degrees" is NOT used with Kelvin.) The way to convert from degrees Celsius to Kelvin is:

Celsius to Kelvin:

$$K = {}^{\circ}C + 273.$$

The three different temperature scales have been placed side-by-side in the chart below for comparison.

Temperature Scales

Fahrenheit	Celsius	Kelvin	
212	100	373	Boiling point of water at sea-level
194	90	363	
176	80	353	
158	70	343	
140	60	333	
122	50	323	
104	40	313	
86	30	303	
68	20	293	Average room temperature
50	10	283	
32	0	273	Melting (freezing) point of ice (water) at sea-level
14	-10	263	
-4	-20	253	
-22	-30	243	
-40	-40	233	
-58	-50	223	
-76	-60	213	
-94	-70	203	
-112	-80	193	-89°C (-129 °F) Lowest recorded temperature. Vostok, Antarctica July, 1983
-130	-90	183	
-148	-100	173	

Reference: Ahrens (1994)

Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign

Image adapted from: Ahrens

UTC Conversions

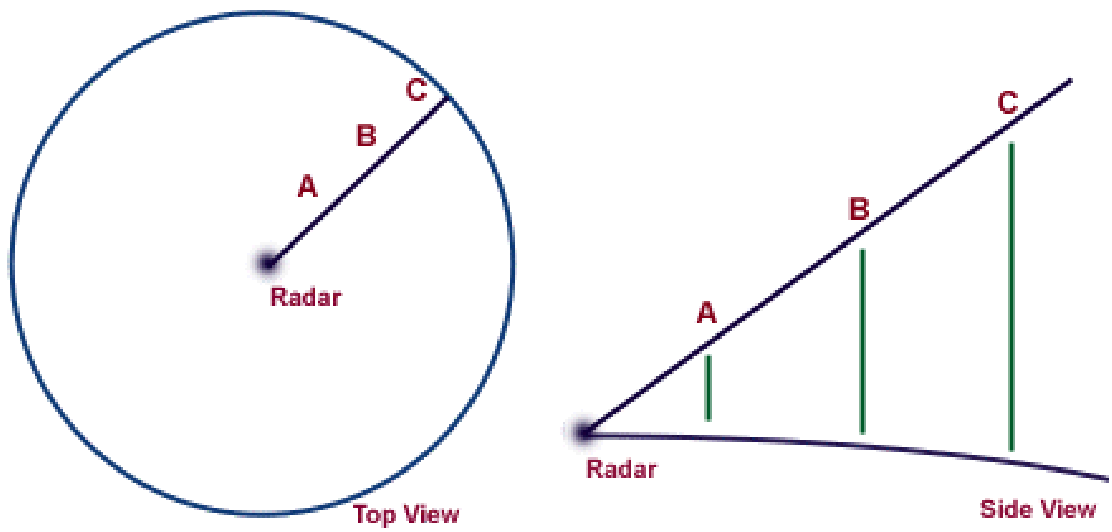
Terms for using data resources. CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

Surface Obs

Interpreting Doppler Radar Velocities

speed shear wind patterns

To understand Doppler radial velocity patterns, one first has to consider the geometry of a radar scan. Normally the radar beam is pointed at an elevation angle greater than zero so that the beam, as it moves away from the radar, moves higher and higher above the surface of the earth. Because of this geometry, radar returns originating from targets near the radar represent the low-level wind field, while returns from distant targets represent the wind field at higher levels.



On a radar PPI display, the distance away from the radar at the center of the display represents both a change in horizontal distance and a change in vertical distance. To determine the wind field at a particular elevation above the radar, one must examine the radial velocities on a ring at a fixed distance from the radar. The exact elevation represented by a particular ring depends upon the elevation angle of the radar beam.

In the examples below, idealized Doppler radial velocity patterns were constructed with a computer assuming simple vertical wind field patterns. These simplified radial velocity patterns can help us understand the more complicated patterns that are associated with storm motions. Doppler velocity patterns (right) correspond to vertical wind profiles (left), where the wind barbs indicate wind speed and direction from the ground up to 24,000 feet. Negative Doppler velocities (blue-green) are toward the radar and positive (yellow-red) are away. The radar location is at the center of the display.

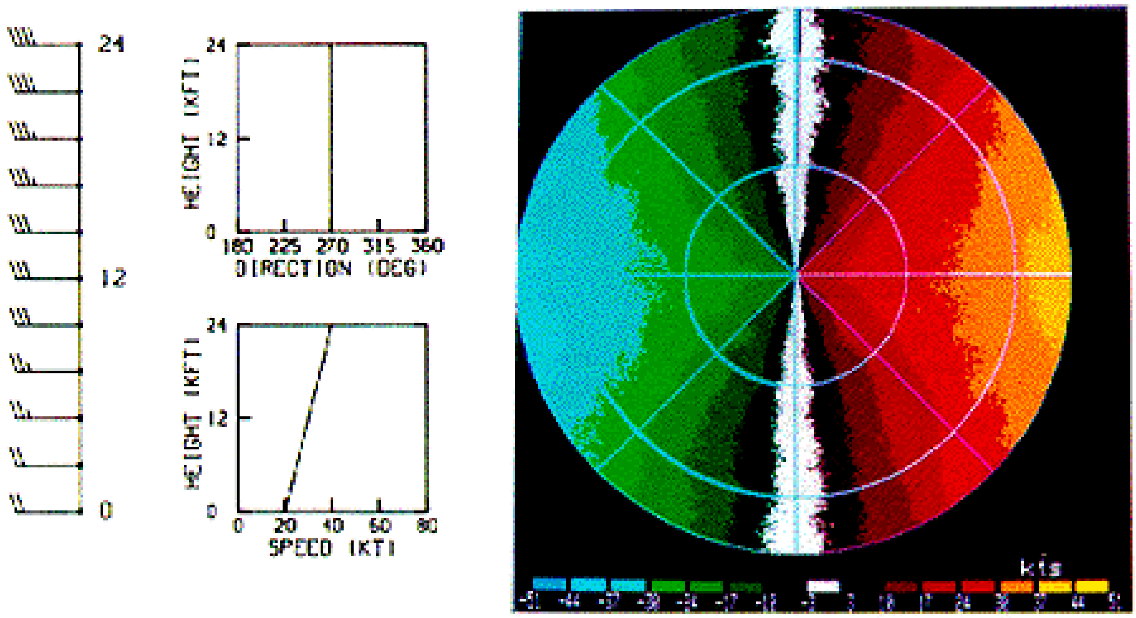


Image by: [Brown & Wood]

For this first example, wind direction is constant with height, but wind speed increases from 20 knots at the ground to 40 knots at 24,000 feet. Note on the radial velocity field that the maximum inbound velocity is to the west and maximum outbound to the east while to the north and south the radar measures zero radial velocity. This is because the winds are perpendicular to the radar beam when viewed to the north or south.

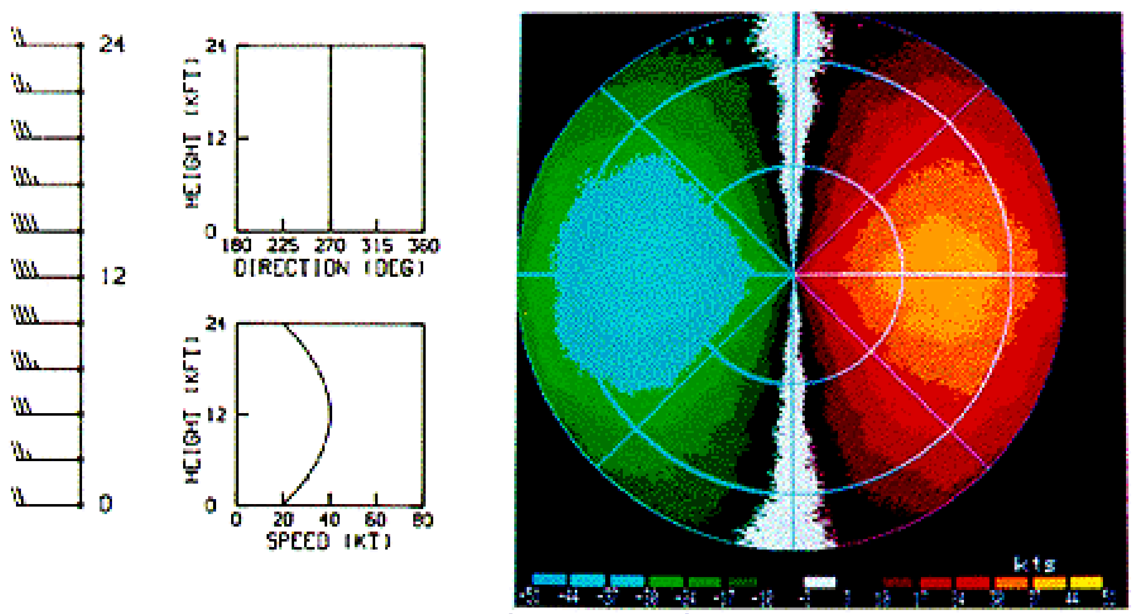


Image by: Brown & Wood

In the second example, the winds increase from 20 to 40 knots between zero and 12,000 feet and then decrease again to 20 knots at 24,000 feet. The wind direction again is constant. The radar beam intersects the 12,000 foot level along a ring half-way across the radar display. This is where we see the maximum inbound and outbound velocities.

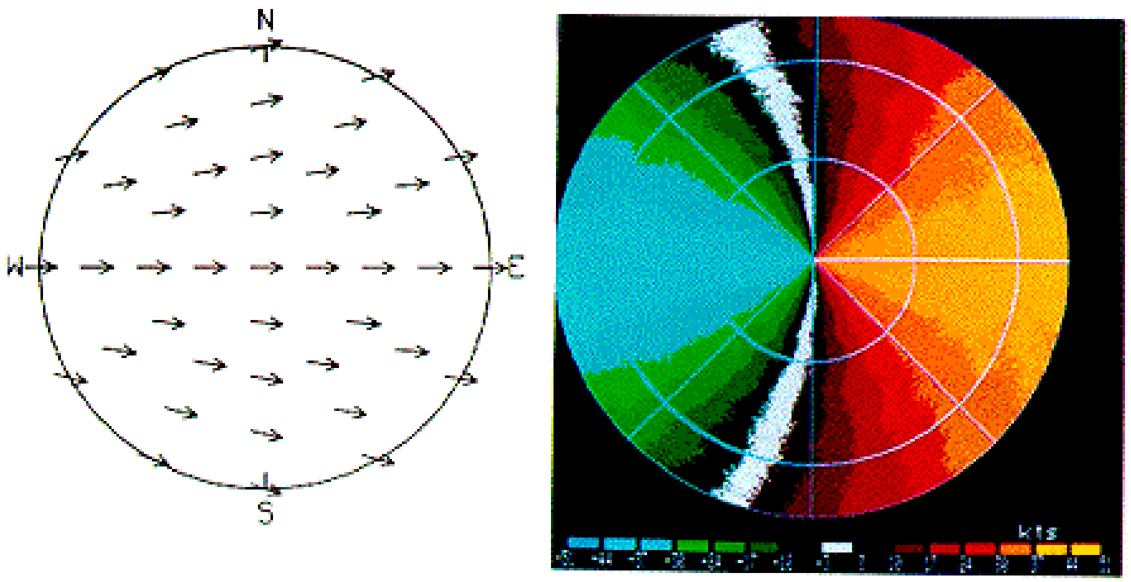


Image by: [Brown & Wood]()

In the third example, we see a wind field which changes direction from north to south but has a constant speed at all heights. The zero radial velocity line now bends so that it is everywhere perpendicular to the wind field. The maximum [radial velocities]() are observed where the radar beam points directly toward or away from the wind direction.

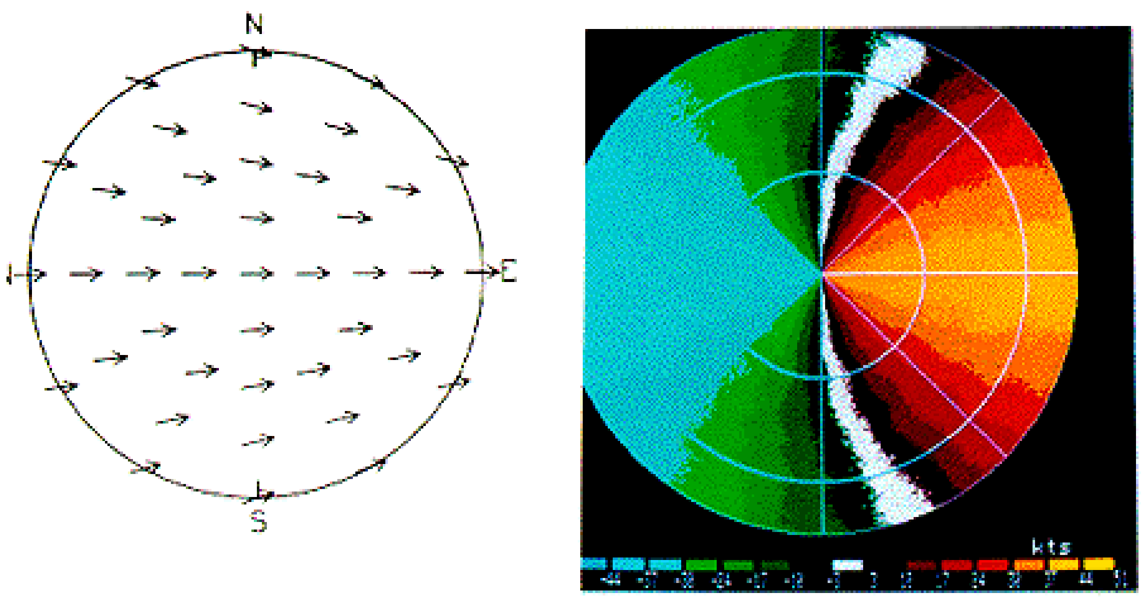


Image by: [Brown & Wood]()

In our fourth example, we see the same effect but in this case, the flow is confluent instead of difluent.

Imagery

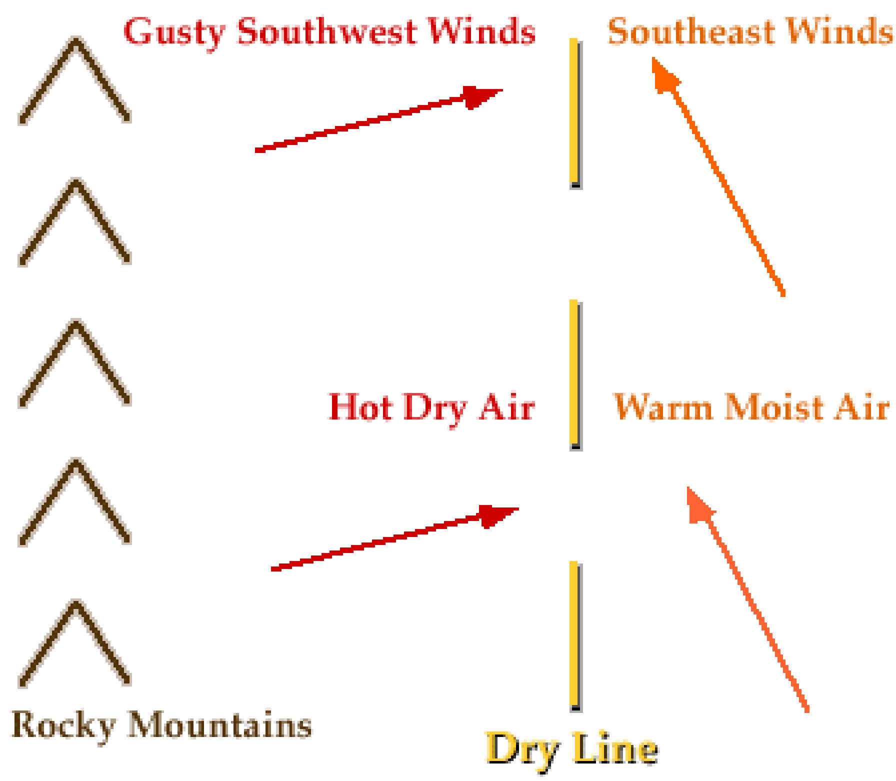
directional shear

Dry Line

a moisture boundary

Forecast Tip:
If a dryline is approaching your region, predict that air will be much drier after the boundary moves through. Storms are possible as the dryline approaches. The temperature may rise after the dryline passes through, since dry air heats up more quickly than moist air.

A dryline is a boundary that separates a moist air mass from a dry air mass. A dryline is also called a **Dew Point Front**. Sharp changes in dew point temperature can be found across a dryline (sometimes 9 degrees **Celsius** per kilometer). Drylines are most commonly found just east of the Rocky Mountains, separating a warm, moist air mass to the east from a hot, dry air mass to the west (see diagram below).



States like Texas, New Mexico, Oklahoma, Kansas, and Nebraska frequently experience drylines in the spring and summer, while east of the Mississippi River, drylines are extremely rare. The dryline is represented on surface maps by a dashed yellow line (see example below).

Dew points east of the dryline shown above range from the upper 50's to low 70's, with winds from the southeast. West of the dryline, dew points are much lower, in the 20's and 30's, which is almost 50 degrees less than those found east of the dryline.

Air temperature ahead of the dryline is generally in the 70's and 80's. Behind the dryline, temperatures are hotter, ranging from the mid 80's to mid 90's. The drier air behind the dryline lifts the moist air ahead of it as it advances, which could lead to the development of thunderstorms along and ahead of the dryline in a manner similar to how thunderstorms develop along cold fronts.

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occluded fronts

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at the University of Illinois at Urbana-Champaign.

Temperatures

A Developing Supercell Intensifies

precipitation and winds intensify, rotation develops

This was initially a small supercell, looking west from about 8 miles, that packed a very intense rotating updraft. The rain curtains extending beneath the storm base were rotating, and looked very much like the rain areas we have seen under HP supercell bases. Once again, note the vaulted appearance on the north (right) side of the updraft. The storm was producing baseball size hail at this time, and a low-pitched, subtle, and continuous roaring sound was heard. Storm chasers have heard this a number of times, particularly close to LP storms, and attribute it to hailfall.

Photograph by: Moller

Below is a northward view of the storm's main precipitation area. It has the nearly transparent look of an LP storm. The radar echo at this time showed a relatively small VIP 4 storm, although a small radar pendant was present. A VIP 4 with baseball hail! Indeed, it seemed to have mainly LP characteristics, except for the rotating rain curtains wrapping around the updraft base.

Photograph by: Moller

At this time and location, just west of Archer City, Texas, east surface winds were blowing into the supercell at 25 to 30 MPH. We are very close in position to the pseudo-warm front, separating cool outflow coming from this precipitation area to the north from warm air to the south...

Tornadoes

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tornado develops

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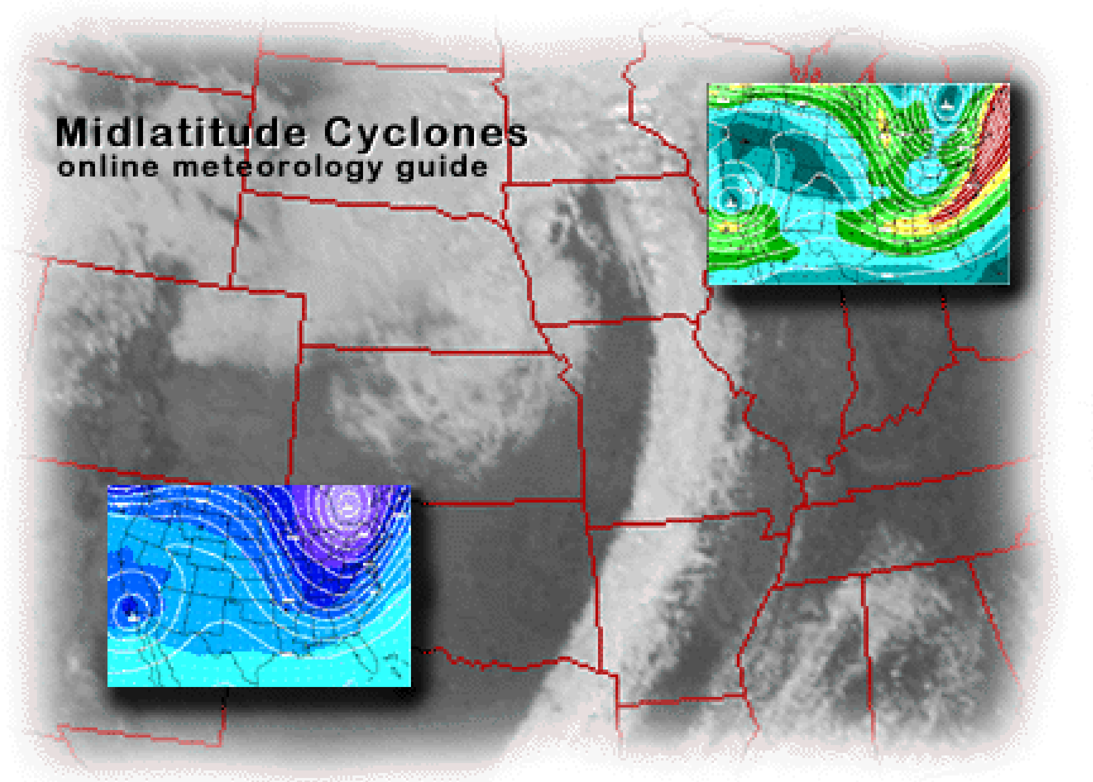
Midlatitude Cyclones

bringing weather change



Graphic by: Ed Mlodzik

Midlatitude cyclones are the cause of most of the stormy weather in the United States, espeically during the winter season. Understanding the structure and evolution of midlatitude cyclones is crucial for predicting significant weather phenomena such as blizzards, flooding rains, and severe weather.

A midlatitude cyclone is an area of low pressure located between 30 degrees and 60 degrees latitude. Since the continental United States is located in this latitude belt, these cyclones impact the weather in the U.S.

This instructional module introduces the most important features of midlatitude cyclones. The module is divided into the following sections:

Sections

Last Update: 08/22/97

The navigation menu (left) for this module is called "Midlatitude Cyclones" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Rainbows

definition

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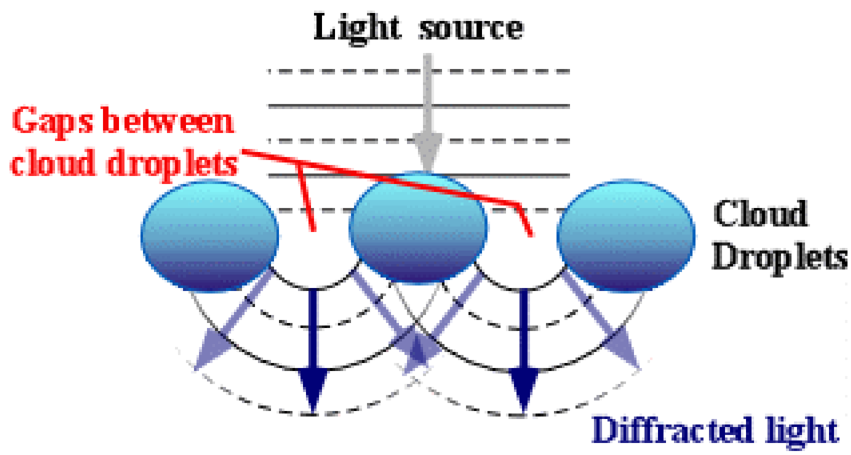
Diffraction of Light

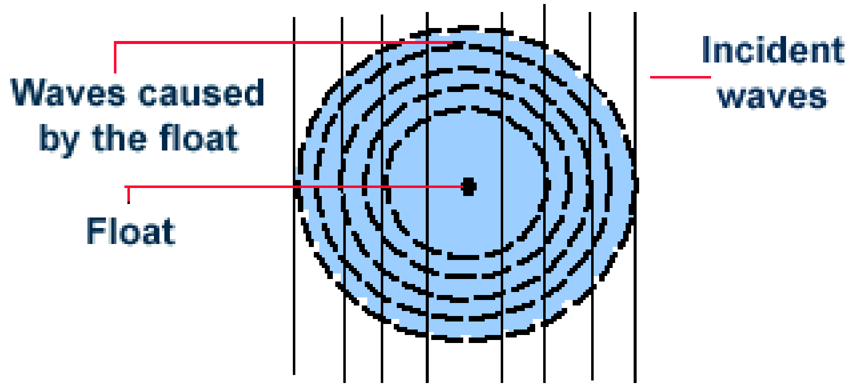
light bending around an object

Diffraction is the slight bending of light as it passes around the edge of an object. The amount of bending depends on the relative size of the wavelength of light to the size of the opening. If the opening is much larger than the light's wavelength, the bending will be almost unnoticeable. However, if the two are closer in size or equal, the amount of bending is considerable, and easily seen with the naked eye.



In the atmosphere, diffracted light is actually bent around atmospheric particles -- most commonly, the atmospheric particles are tiny water droplets found in clouds. Diffracted light can produce fringes of light, dark or colored bands. An optical effect that results from the diffraction of light is the silver lining sometimes found around the edges of clouds or coronas surrounding the sun or moon. The illustration above shows how light (from either the sun or the moon) is bent around small droplets in the cloud.

Optical effects resulting from diffraction are produced through the interference of light waves. To visualize this, imagine light waves as water waves. If water waves were incident upon a float residing on the water surface, the float would bounce up and down in response to the incident waves, producing waves of its own. As these waves spread outward in all directions from the float, they interact with other water waves. If the crests of two waves combine, an amplified wave is produced (constructive interference). However, if a crest of one wave and a trough of another wave combine, they cancel each other out to produce no vertical displacement (destructive interference).



This concept also applies to light waves. When sunlight (or moonlight) encounters a cloud droplet, light waves are altered and interact with one another in a similar manner as the water waves described above. If there is constructive interference, (the crests of two light waves combining), the light will appear brighter. If there is destructive interference, (the trough of one light wave meeting the crest of another), the light will either appear darker or disappear entirely.

Refraction

air, dust, haze

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Convergence Associated With Cyclones

extra-tropical and tropical cyclones

Both extra-tropical and tropical cyclones, like this hurricane, can cause air to rise. This type of lifting is different from the lifting produced along frontal boundaries.

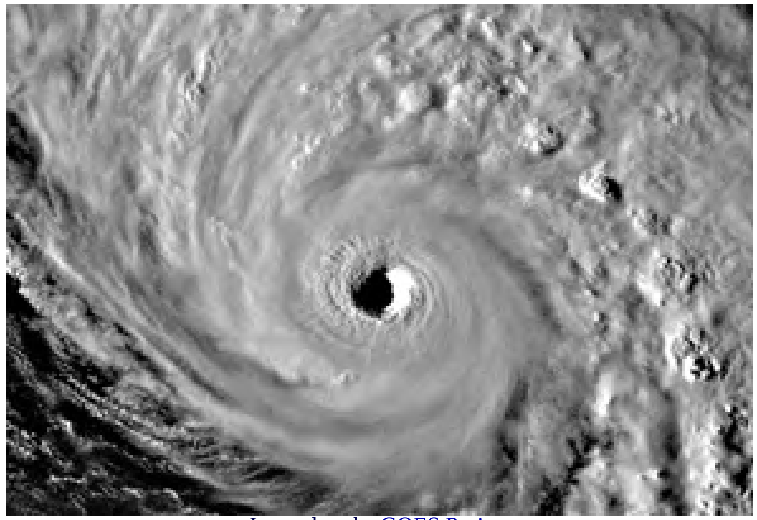
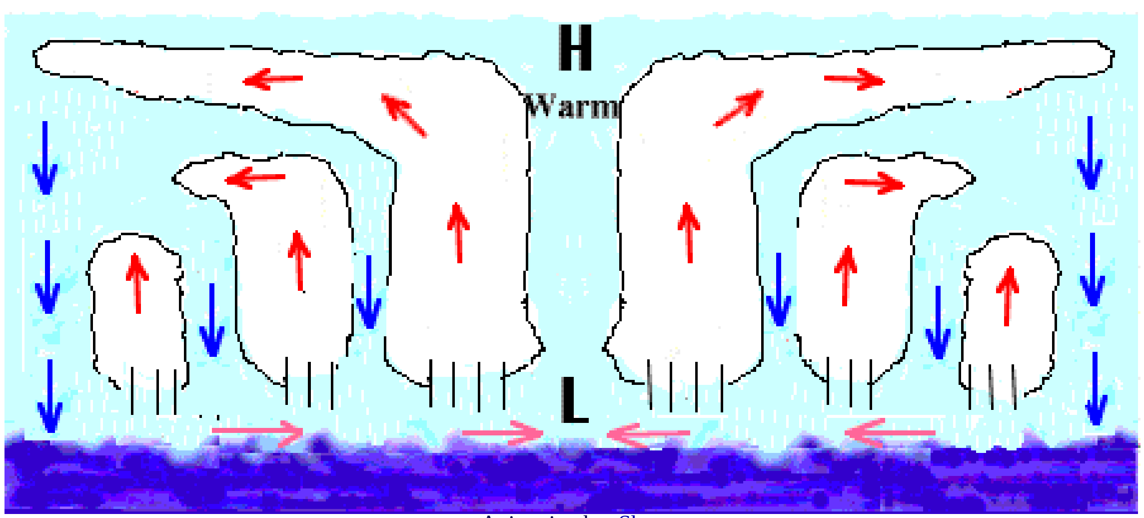


Image by: the GOES Project

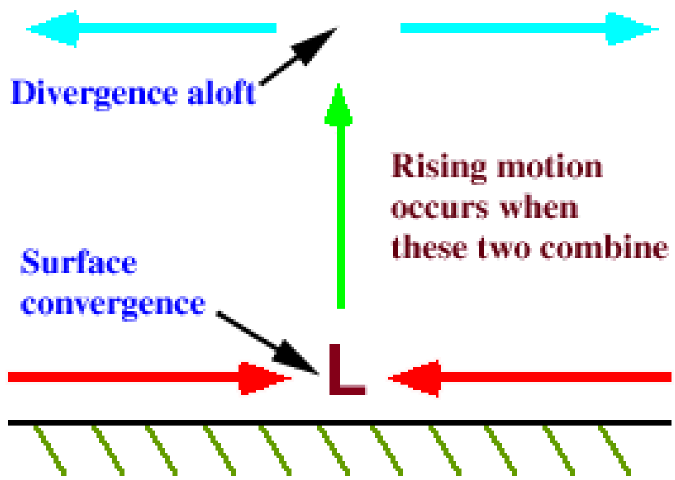
In hurricanes, condensation occurs through a process known as CISK (Convective Instability of the Second Kind). We will demonstrate CISK by referring to the animated cross-section through a mature hurricane given below. In CISK, surface convergence (pink horizontal arrows) causes rising motion around a surface cyclone (labeled as "L"). The air cools as it rises (red vertical arrows) and condensation occurs, which releases latent heat into the atmosphere. This heating causes air to expand, creating an area of high pressure aloft. The force resulting from the established pressure gradient causes air to diverge at upper levels (red horizontal arrows).



Animation by: Shao

Since pressure is a measure of the weight of the air above a unit area, removal of air at upper levels subsequently reduces pressure at the surface. A further reduction in surface pressure leads to increasing convergence (due to an intensified pressure gradient), which further intensifies the rising motion, latent heat release, and so on. Despite the absence of fronts, a tremendous amount of lifting occurs in hurricanes, with intense condensation leading to the development of deep clouds and heavy rainfall.

In extra-tropical cyclones, surface winds are deflected by friction towards the center of the low pressure system (red "L" below).

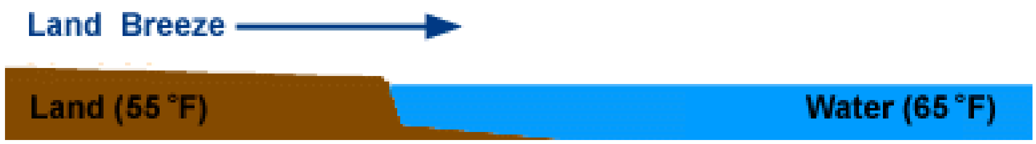


Coupled with divergence aloft, (blue arrows), surface convergence (red arrows) can generate rising motion (green arrow) that leads to the condensation of water vapor.

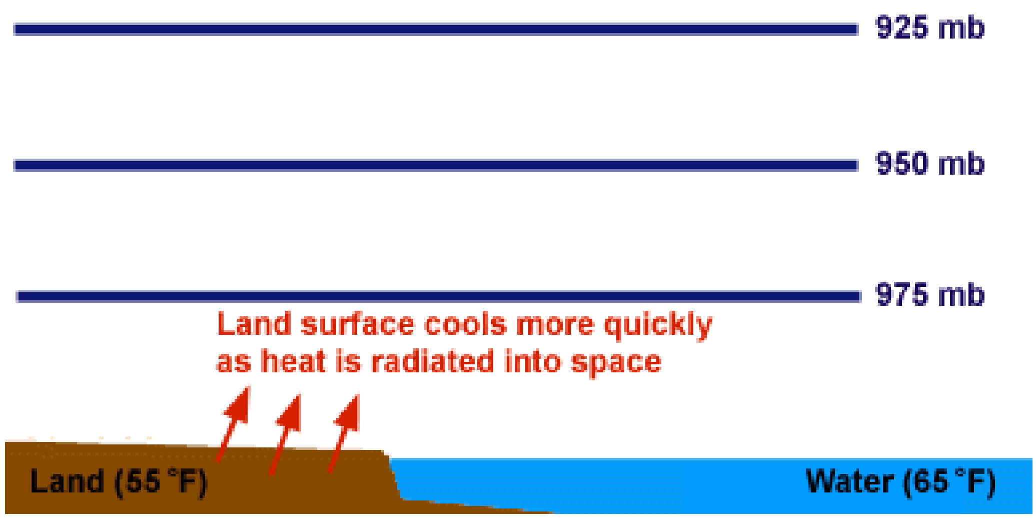
Land Breezes

begin with the cooling of low-level air

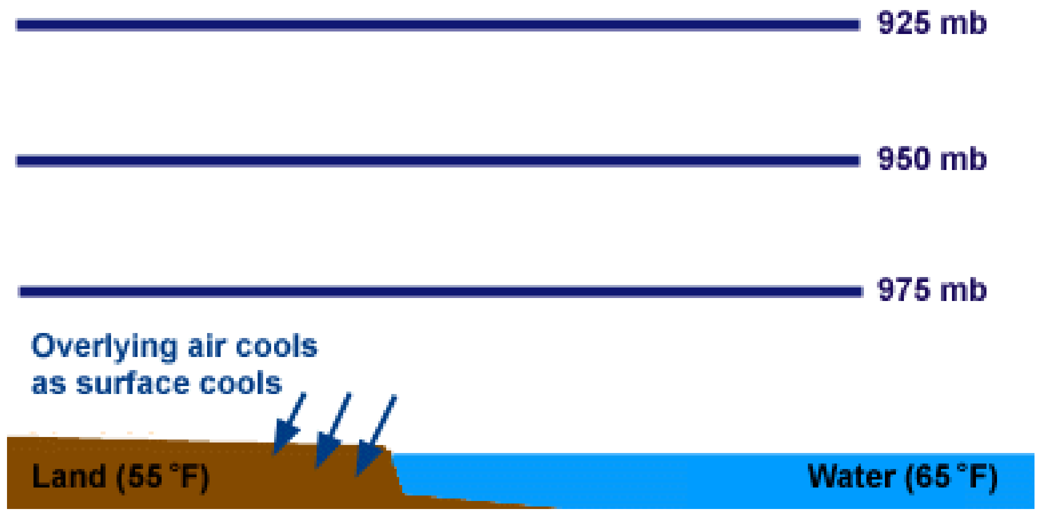
On clear, calm evenings, temperature differences between a body of water and neighboring land produce a cool wind that blows offshore. This wind is called a "land breeze". Land breezes are strongest along the immediate coastline but weaken considerably further inland.



Land-breeze circulations can occur at any time of year, but are most common during the fall and winter seasons when water temperatures are still fairly warm and nights are cool.



On clear and calm evenings, the earth's surface cools by radiating (giving off) heat back into space, and this results in a cooling of the immediately overlying air.



Since the air over land cools more rapidly than the air over water, a temperature difference is established, with cooler air present over land and relatively warmer air located over water.

Sea Breezes

onshore flow aloft

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El Niño

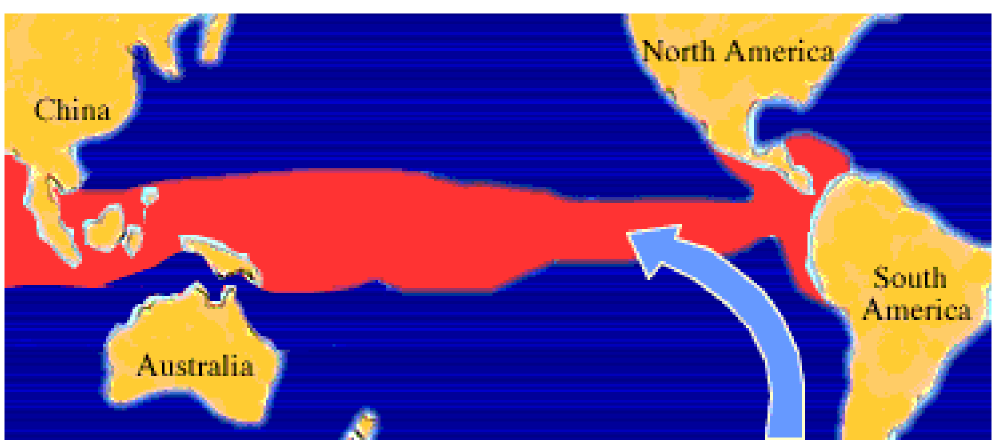
a warm current of water

El Niño (Spanish name for the male child), initially referred to a weak, warm current appearing annually around Christmas time along the coast of Ecuador and Peru and lasting only a few weeks to a month or more. Every three to seven years, an El Niño event may last for many months, having significant economic and atmospheric consequences worldwide. During the past forty years, ten of these major El Niño events have been recorded, the worst of which occurred in 1997-1998. Previous to this, the El Niño event in 1982-1983 was the strongest. Some of the El Niño events have persisted more than one year.

El Niño Years			
1902-1903	1905-1906	1911-1912	1914-1915
1918-1919	1923-1924	1925-1926	1930-1931
1932-1933	1939-1940	1941-1942	1951-1952
1953-1954	1957-1958	1965-1966	1969-1970
1972-1973	1976-1977	1982-1983	1986-1987
1991-1992	1994-1995	1997-1998	

Selected text from: CPC ENSO Main Page

In the tropical Pacific, trade winds generally drive the surface waters westward. The surface water becomes progressively warmer going westward because of its longer exposure to solar heating. El Niño is observed when the easterly trade winds weaken, allowing warmer waters of the western Pacific to migrate eastward and eventually reach the South American Coast (shown in orange). The cool nutrient-rich sea water normally found along the coast of Peru is replaced by warmer water depleted of nutrients, resulting in a dramatic reduction in marine fish and plant life.



Animation by: Shao

In contrast to El Niño, La Niña (female child) refers to an anomaly of unusually cold sea surface temperatures found in the eastern tropical Pacific. La Niña occurs roughly half as often as El Niño.

La Niña Years			
1904-1905	**1909-1910**	**1910-1911**	**1915-1916**
1917-1918	**1924-1925**	**1928-1929**	**1938-1939**
1950-1951	**1955-1956**	**1956-1957**	**1964-1965**
1970-1971	**1971-1972**	**1973-1974**	**1975-1976**
1988-1989	**1995-1996**		

Selected text from: CPC ENSO Main Page

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'97-'98 event

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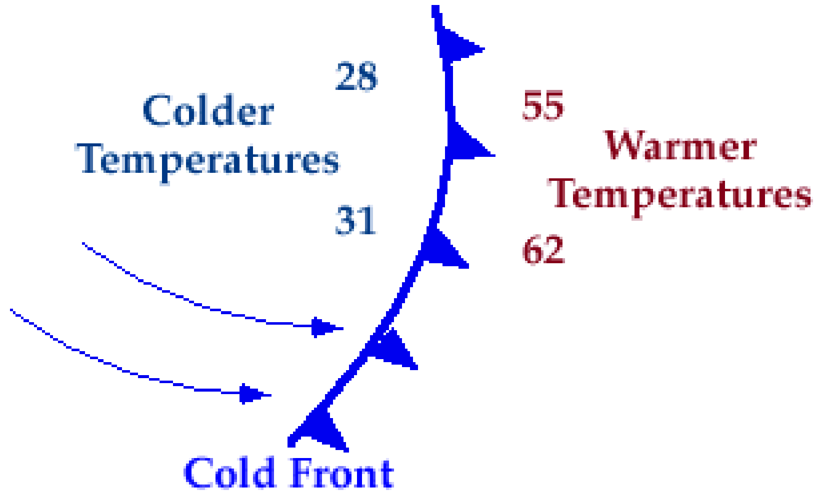
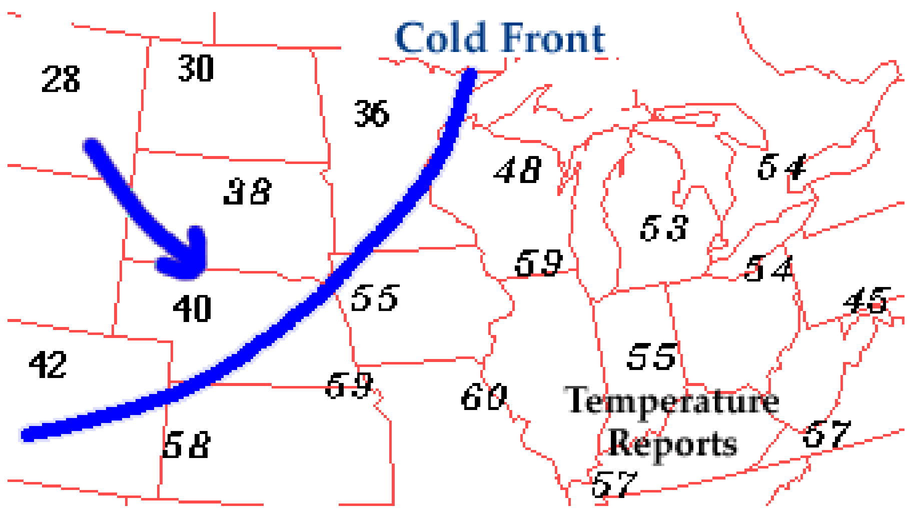
Cold Front

transition zone from warm air to cold air

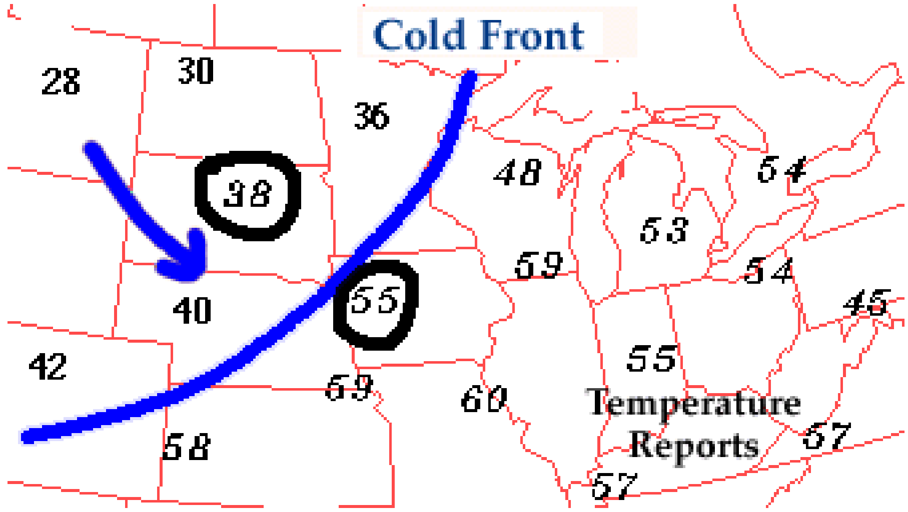
A cold front is defined as the transition zone where a cold air mass is replacing a warmer air mass. Cold fronts generally move from northwest to southeast. The air behind a cold front is noticeably colder and drier than the air ahead of it. When a cold front passes through, temperatures can drop more than 15 degrees within the first hour.



Symbolically, a cold front is represented by a solid line with triangles along the front pointing towards the warmer air and in the direction of movement. On colored weather maps, a cold front is drawn with a solid blue line.



There is typically a noticeable temperature change from one side of a cold front to the other. In the map of surface temperatures below, the station east of the front reported a temperature of 55 degrees Fahrenheit while a short distance behind the front, the temperature decreased to 38 degrees. An abrupt temperature change over a short distance is a good indicator that a front is located somewhere in between.



If colder air is replacing warmer air, then the front should be analyzed as a cold front. On the other hand, if warmer air is replacing cold air, then the front should be analyzed as a warm front. Common characteristics associated with cold fronts have been listed in the table below.

	Before Passing	**While Passing**	**After Passing**
Winds	south-southwest	gusty; shifting	west-northwest
Temperature	warm	sudden drop	steadily dropping
Pressure	falling steadily	minimum, then sharp rise	rising steadily
Clouds	increasing: Ci, Cs and Cb	Cb	Cu
Precipitation	short period of showers	heavy rains, sometimes with hail, thunder and lightning	showers then clearing
Visibility	fair to poor in haze	poor, followed by improving	good, except in showers
Dew Point	high; remains steady	sharp drop	lowering

Table adapted from: Ahrens, (1994)

Fronts

wind shift

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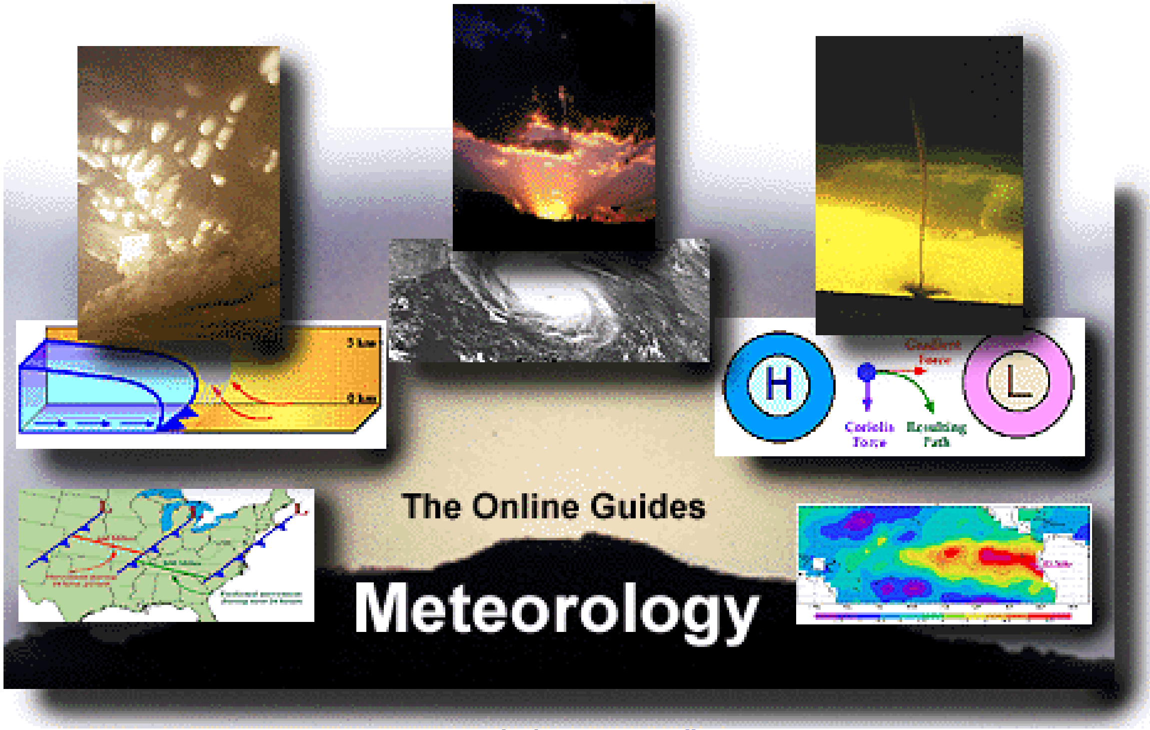

Graphic by: Steven E. Hall

The Online Meteorology Guide is a collection of web-based instructional modules that use multimedia technology and the dynamic capabilities of the web. These resources incorporate text, colorful diagrams, animations, computer simulations, audio and video to introduce fundamental concepts in the atmospheric sciences. Selected pages link to (or will soon link to) relevant classroom activities and current weather products to reinforce topics discussed in the modules and allow the user to apply what has been learned to real-time weather data. Available modules include:

Modules

Last Update: 09/02/99

Light and Optics
The interaction between light and atmospheric particles and the colorful optical effects that result.

Clouds and Precipitation
Cloud classifications and the processes by which clouds and precipitation develop.

Forces and Winds
Forces that influence the flow of air and how they interact to produce wind.

Air Masses and Fronts
The most common types of air masses and fronts, plus a look at the different types of advection.

Weather Forecasting
General forecasting methods, important surface features, plus forecasting tips for different scenarios.

Severe Storms

The online version of NOAA's Severe Storm Spotters Guide. Investigates the different types of thunderstorms, their associated components, plus an in depth look at tornadoes.

Hurricanes
The anatomy of hurricanes, how they develop and why they are so dangerous.

El Niño
Why El Niño develops and the global impact it has on weather patterns and economics.

Hydrologic Cycle
The circulation and conservation of the earth's water.

The target audience for the Online Meteorology Guide is high school and undergraduate level students. However, these resources have been used by instructors throughout K-12, undergraduate and graduate level education. Contents of the Online Meteorology Guide were developed by graduate students and faculty through our efforts in the Collaborative Visualization Project (CoVis), which was funded by the National Science Foundation. These resources have been reviewed by faculty and scientists at the University of Illinois and the Illinois State Water Survey. Many of these resources were tested in a classroom environment and have been modified based upon teacher and student feedback.

The navigation menu (left) for this module is called "Meteorology" and the available modules are listed as menu items, beginning with this introduction. Click on the menu item of interest to go to that particular module. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

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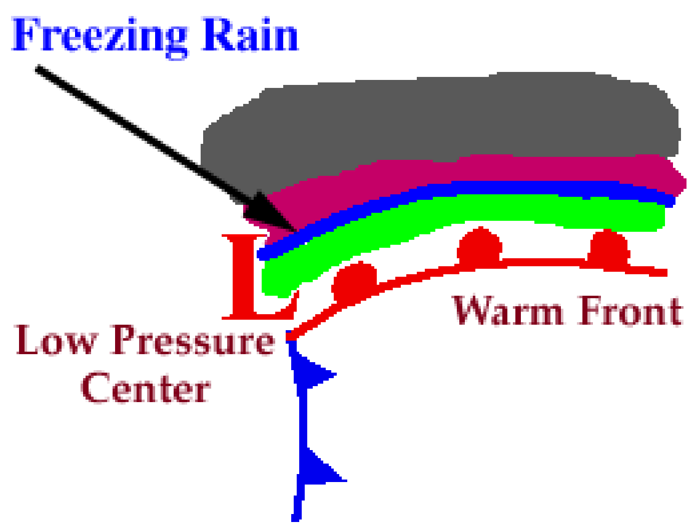
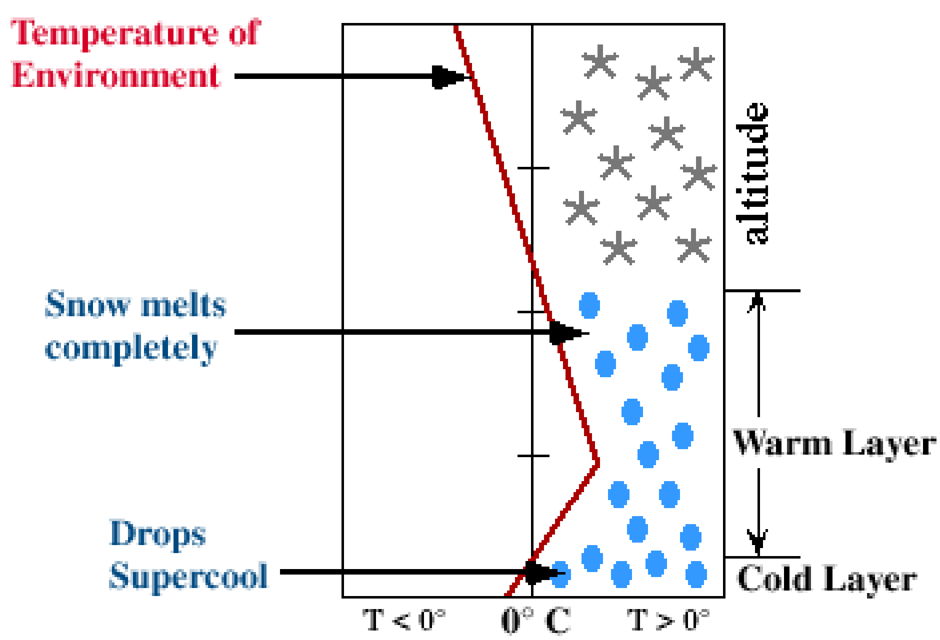
Freezing Rain

supercooled droplets freezing on impact

Ice storms can be the most devastating of winter weather phenomena and are often the cause of automobile accidents, power outages and personal injury. Ice storms result from the accumulation of freezing rain, which is rain that becomes supercooled and freezes upon impact with cold surfaces. Freezing rain is most commonly found in a narrow band on the cold side of a warm front, where surface temperatures are at or just below freezing.



The diagram below shows a typical temperature profile for freezing rain with the red line indicating the atmosphere's temperature at any given altitude. The vertical line in the center of the diagram is the freezing line. Temperatures to the left of this line are below freezing, while temperatures to the right are above freezing.



Freezing rain develops as falling snow encounters a layer of warm air deep enough for the snow to completely melt and become rain. As the rain continues to fall, it passes through a thin layer of cold air just above the surface and cools to a temperature below freezing. However, the drops themselves do not freeze, a phenomena called supercooling (or forming "supercooled drops"). When the supercooled drops strike the frozen ground (power lines, or tree branches), they instantly freeze, forming a thin film of ice, hence freezing rain.

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Cirrus Clouds

thin and wispy

The most common form of high-level clouds are thin and often wispy cirrus clouds. Typically found at heights greater than 20,000 feet (6,000 meters), cirrus clouds are composed of ice crystals that originate from the freezing of supercooled water droplets. Cirrus generally occur in fair weather and point in the direction of air movement at their elevation.

Cirrus can form from almost any cloud that has undergone glaciation and can be observed in a variety of shapes and sizes. Possibilities range from the "finger-like" appearance of cirrus fall streaks to the uniform texture of more extensive cirrus clouds associated with an approaching warm front.

Photograph by: Holle

Fall streaks form when snowflakes and ice crystals fall from cirrus clouds. The change in wind with height and how quickly these ice crystals fall determine the shapes and sizes the fall streaks attain. Since ice crystals fall much more slowly than raindrops, fall streaks tend to be stretched out horizontally as well as vertically. Cirrus streaks may be nearly straight, shaped like a comma, or seemingly all tangled together.

Similar to fall streaks is virga, which appears as streamers suspended in the air beneath the base of precipitating clouds. Virga develops when precipitation falls through a layer of dry air and evaporates before reaching the ground.

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Relative Humidity

indicates how moist the air is

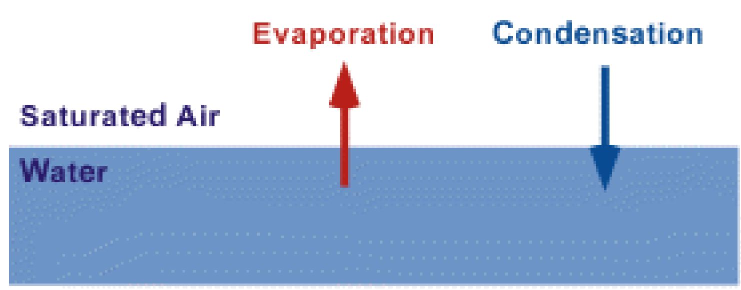
Relative humidity may be defined as the ratio of the water vapor density (mass per unit volume) to the saturation water vapor density, usually expressed in percent:

$$\textbf{Relative Humidity (RH)} = \frac{\text{(Actual Vapor Density)}}{\text{(Saturation Vapor Density)}} \times 100\%$$

Relative humidity is also approximately the ratio of the actual to the saturation vapor pressure.

$$\textbf{RH} = \frac{\text{(Actual Vapor Pressure)}}{\text{(Saturation Vapor Pressure)}} \times 100\%$$

Actual vapor pressure is a measurement of the amount of water vapor in a volume of air and increases as the amount of water vapor increases. Air that attains its saturation vapor pressure has established an equilibrium with a flat surface of water. That means, an equal number of water molecules are evaporating from the surface of the water into the air as are condensing from the air back into the water.



Saturation vapor pressure is a unique function of temperature as given in the table below. Each temperature in the table may be interpreted as a dew point temperature, because as the ground cools, dew will begin to form at the temperature corresponding to the vapor pressure in this table.

(C) Temp (F)	Sat Vapor Prs (mb)	(C) Temp (F)	Sat Vapor Prs (mb)

-18	00	1.5	18	65	21.0
-15	05	1.9	21	70	25.0
-12	10	2.4	24	75	29.6
-09	15	3.0	27	80	35.0
-07	20	3.7	29	85	41.0
-04	25	4.6	32	90	48.1
-01	30	5.6	35	95	56.2
02	35	6.9	38	100	65.6
04	40	8.4	41	105	76.2
07	45	10.2	43	110	87.8
10	50	12.3	46	115	101.4
13	55	14.8	49	120	116.8
16	60	17.7	52	125	134.2

Chart adapted from: Ahrens

For example, if the water vapor pressure in the air is 10.2 millibars (mb), dew will form when the ground reaches 45 degrees Fahrenheit (F). The relative humidity for air containing 10.2 mb of water vapor is simply 100% times 10.2 mb divided by the saturation vapor pressure at the actual temperature. For example, at 70 F the saturation vapor pressure is 25 mb, so the relative humidity would be

RH = 100% X (10.21 / 25.0) = 41%

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states of water

rising air

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Clouds, Precipitation

- introduction
- development
- cloud types

[Image: home page image for clouds and precip module (90K)]

Graphic by: Yiqi Shao

A cloud is a visible aggregate of tiny water droplets and/or ice crystals suspended in the atmosphere and can exist in a variety of shapes and sizes. Some clouds are accompanied by precipitation; rain, snow, hail, sleet, even freezing rain. The purpose of this module is to introduce a number of cloud classifications, different types of precipitation, and the mechanisms responsible for producing them. The Clouds and Precipitation module has been organized into the following sections:

Sections

Last Update: 07/21/97

Development
The importance of rising motion and the mechanisms responsible for lifting the air.

Cloud Types
High, middle and low-level clouds, vertically developed clouds, plus some less common cloud types.

Precipitation
Rain, snow, hail, sleet and freezing rain.

Acknowledgments
Those who contributed to the development of this module.

The navigation menu (left) for this module is called "Clouds, Precipitation" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Advection

Development

precipitation

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graphicstext

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Clouds and Precipitation

contributors to module development

WW2010 Personnel (Clouds):

Steven E. Hall - Content Developer and Editor - Scanned in slides, constructed original text and diagrams. Responsible for new layout, organization and cross linking of helper pages. Implemented text and graphics modifications as recommended by the Content Reviewers.

John Walsh - Content Reviewer - Professor of Atmospheric Sciences who edited module text and diagrams for scientific accuracy.

Ken Beard - Content Reviewer - Professor of Atmospheric Sciences who edited module text and diagrams for scientific accuracy.

Mythili Sridhar - Graphics Assistant- Graphically enhanced previous version of this module.

Yiqi Shao - HTML Programmer and Graphics Assistant - Helped with the integration of this module into the WW2010 format and constructed home page graphic.

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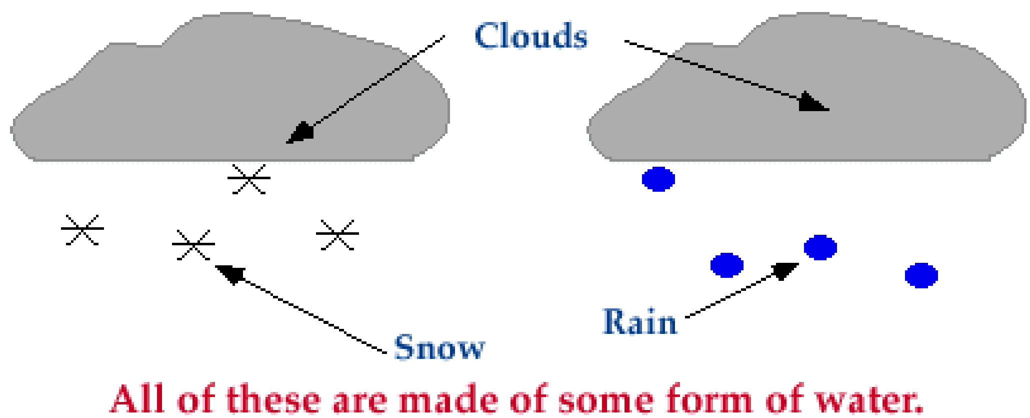
The States of Water

solid, liquid, gas

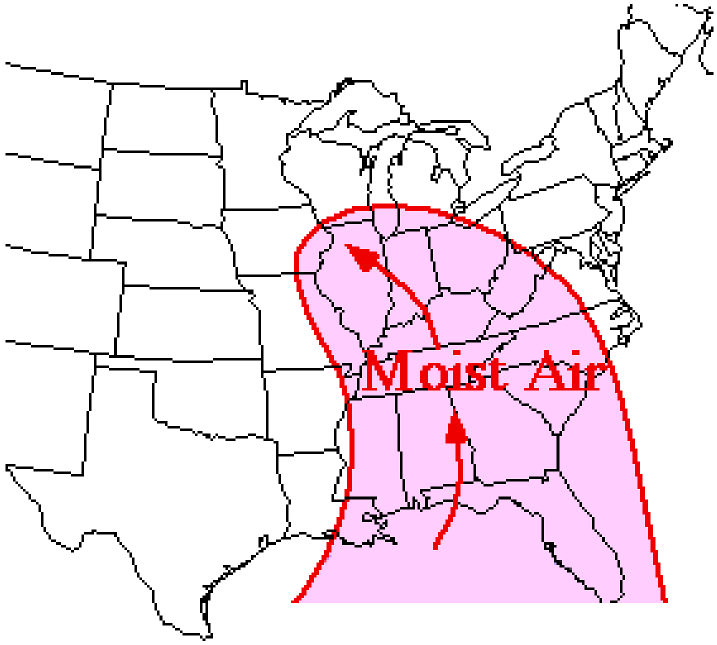
Water is known to exist in three different states; as a solid, liquid or gas.

Clouds, snow, and rain are all made of up of some form of water. A cloud is comprised of tiny water droplets and/or ice crystals, a snowflake is an aggregate of many ice crystals, and rain is just liquid water.



Water existing as a gas is called water vapor. When referring to the amount of moisture in the air, we are actually referring to the amount of water vapor. If the air is described as "moist", that means the air contains large amounts of water vapor. Common sources of moisture for the United States are the warm moist air masses that flow northward from the Gulf of Mexico and western Atlantic Ocean as well as the moist Pacific air masses brought onshore by the westerlies.

As cyclones move eastward from the Rocky Mountains, southerly winds ahead of these storm systems transport the warm moist air northward. Moisture is a necessary ingredient for the production of clouds and precipitation.



Clouds, Precipitation

relative humidity

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Cloud Types

common cloud classifications

Clouds are classified into a system that uses Latin words to describe the appearance of clouds as seen by an observer on the ground. The table below summarizes the four principal components of this classification system (Ahrens, 1994).

Latin Root	Translation	Example
cumulus	heap	fair weather cumulus
stratus	layer	altostratus
cirrus	curl of hair	cirrus
nimbus	rain	cumulonimbus

Further classification identifies clouds by height of cloud base. For example, cloud names containing the prefix "cirr-", as in cirrus clouds, are located at high levels while cloud names with the prefix "alto-", as in altostratus, are found at middle levels. This module introduces several cloud groups. The first three groups are identified based upon their height above the ground. The fourth group consists of vertically developed clouds, while the final group consists of a collection of miscellaneous cloud types.

Photograph by: Knupp

High-Level Clouds

High-level clouds form above 20,000 feet (6,000 meters) and since the temperatures are so cold at such high elevations, these clouds are primarily composed of ice crystals. High-level clouds are typically thin and white in appearance, but can appear in a magnificent array of colors when the sun is low on the horizon.

Photograph by: Holle

Mid-Level Clouds

The bases of mid-level clouds typically appear between 6,500 to 20,000 feet (2,000 to 6,000 meters). Because of their lower altitudes, they are composed primarily of water droplets, however, they can also be composed of ice crystals when temperatures are cold enough.

Low-level Clouds

- Low clouds are of mostly composed of water droplets since their bases generally lie below 6,500 feet (2,000 meters). However, when temperatures are cold enough, these clouds may also contain ice particles and snow.

Photograph by: Holle

Vertically Developed Clouds

Probably the most familiar of the classified clouds is the cumulus cloud. Generated most commonly through either thermal convection or frontal lifting, these clouds can grow to heights in excess of 39,000 feet (12,000 meters), releasing incredible amounts of energy through the condensation of water vapor within the cloud itself.

Photograph by: Holle

Other Cloud Types

Finally, we will introduce a collection of miscellaneous cloud types which do not fit into the previous four groups.

Classifications

Last Update: 07/09/97

High-Level Clouds
Cloud types include: cirrus and cirrostratus.

Mid-Level Clouds
Cloud types include: altocumulus, altostratus.

Low-Level Clouds
Cloud types include: nimbostratus and stratocumulus.

Clouds with Vertical Development
Cloud types include: fair weather cumulus and cumulonimbus.

Other Cloud Types
Cloud types include: contrails, billow clouds,

mammatus, orographic and pileus clouds.

Development

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

High-Level Clouds

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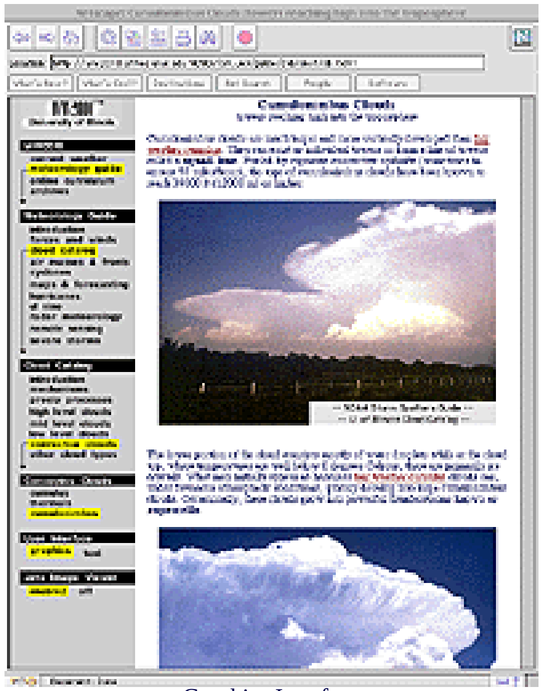
Multiple Interfaces

different interfaces for different connectivity



Graphics Interface

In light of all this, we made it a high priority of WW2010 to not only be able to accommodate the high-bandwidth connections with lots of slick and fancy looking pages...

Text Interface

.

but not to forget that most people are accessing our resources through much slower connections. That is why each and every page is available in both a "graphics" or "text" based interface. In "text" mode, only very small inline images are downloaded.

A graphics-based and text-based example of the same page is shown here and the type of page that appears is controlled by the blue "User Interface" menu (left). The complete graphical representation of each page is obtained by clicking on "graphics", while in the "text" mode, are replaced by text links to these images.

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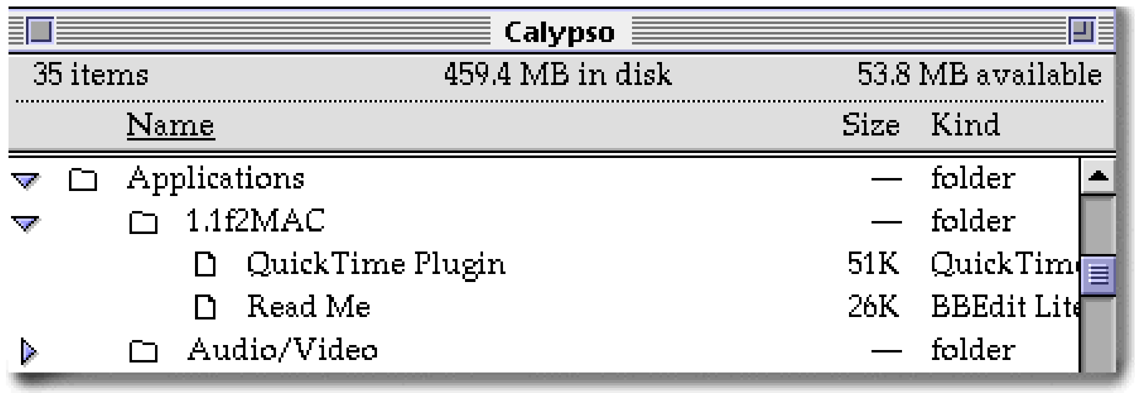
Navigating WW2010

menus and submenus

One of the unique features of WW2010 is the navigation bar along the left side of each page. Each menu resembles a folder on your computer desktop. A folder contains certain items which may either be individual files or additional subfolders, like in the image below.



For each menu, there is a corresponding menu title and the available items in that particular menu are listed below. Your current location within each menu is either highlighted in yellow or indicated by a small red arrow. (The indicator used depends upon the user interface and the web browser being used). In this case, the item "ww2010 user's guide" of the top menu called "Prerelease Info" is marked. This item opens a submenu titled "WW2010 User's Guide" and the item "core technologies" is marked. Then the item "Core Technologies" also contains a submenu of topics and so forth.

About WW2010

information and insights

Welcome...

Thank you for your interest and welcome to WW2010 (Weather World 2010), our evolving earth sciences web server. WW2010 strives to integrate real time and archived data with instructional resources using new and innovative technologies.

This purpose of this section is to introduce some of the new concepts and features that make up WW2010, the philosophies behind their development and how to use them. The WW2010 User's Guide is now available to provide a history of WW2010 plus valuable insights into key components of the web server, namely the content resources and core technologies.

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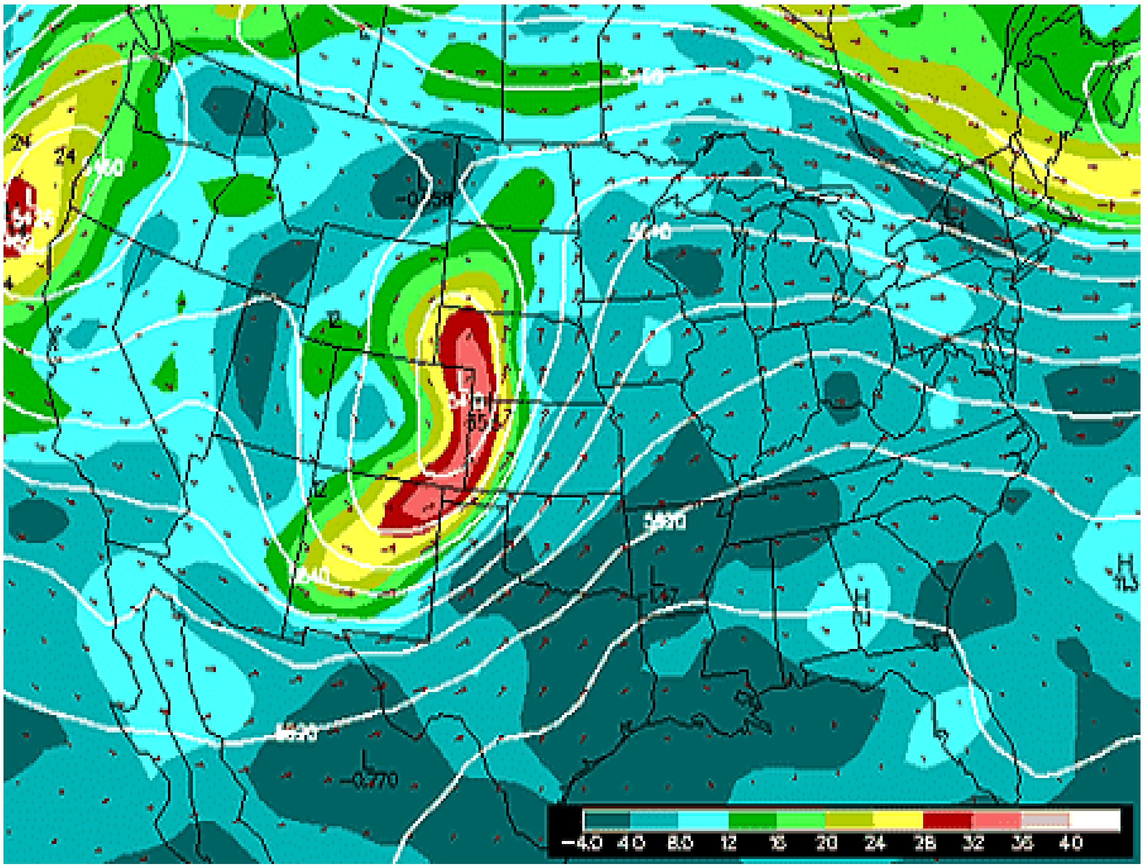
Vorticity Advection

leads to rising/falling pressures at the surface

Vorticity is the localized rotation of the air. Air that rotates counterclockwise, such as in cyclones and troughs, is said to have positive vorticity. Clockwise rotating air, such as in high pressure systems and ridges, has negative vorticity. The advection of vorticity at high levels will result in a response at the surface which will attempt to offset the effects of the advection. More specifically, vorticity advection is indicative of rising motion/falling pressures at the surface. For example, look at this 500 mb map for 12Z, October 29, 1995.



Now look at these two maps of surface pressure (solid lines) from 12Z October 29,1995 and 0Z October 30,1995.

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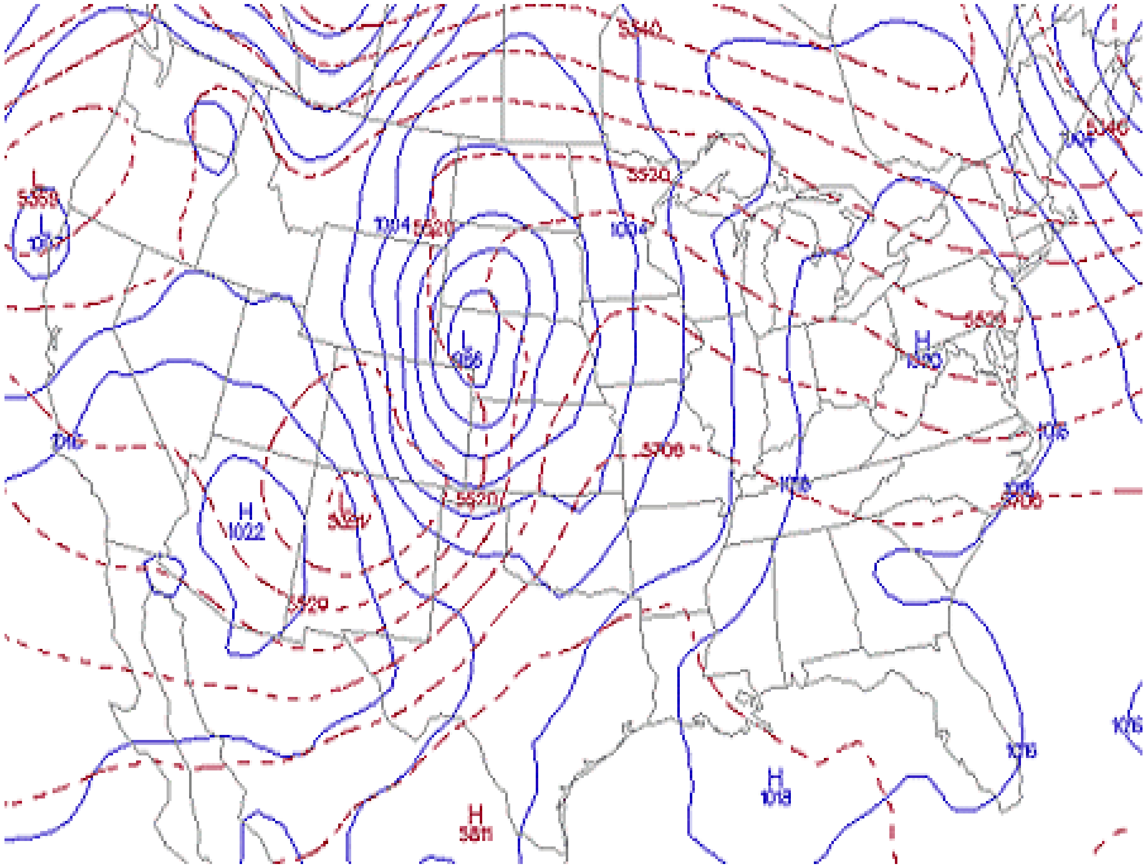
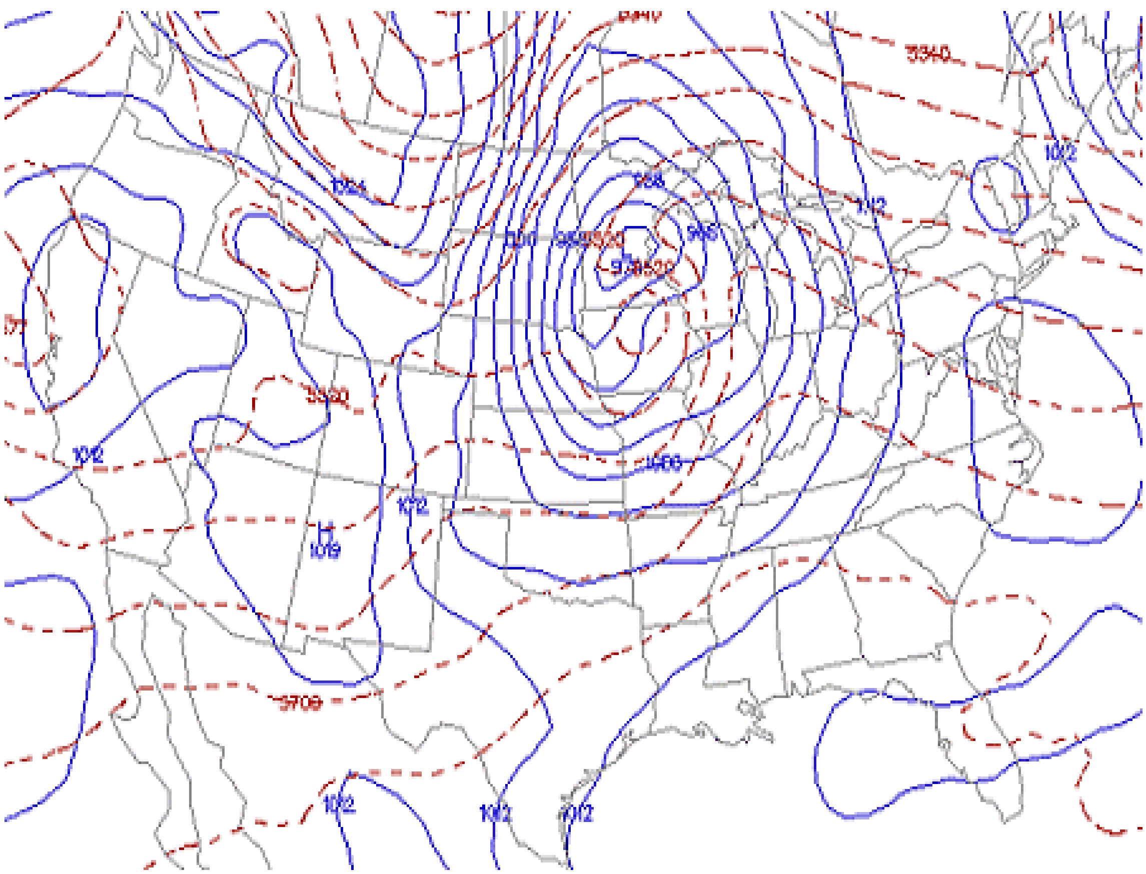


Notice how the surface low has deepened in the area of strong vorticity advection.



moisture advection

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Clouds, Precipitation

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Terms for Using Text, Data and Images

guidelines plus who to contact

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- **Non-Commercial Use:** Non-commercial use must be accompanied by appropriate credit visible with respect to the used item. "Image/Text/Data from the University of Illinois WW2010 Project." Web utilizations should, if possible, provide a link to our server nearby.
- **University of Illinois Copyright:** Content of this server are Copyright © 1997 by the University of Illinois Board of Trustees (except in the the case of photos and other resources which are specifically identified). The names "Weather World 2010" and "WW2010" are trademarks ™ of the University of Illinois.
- **Copyright of Donated Resources:** For resources not developed by the University of Illinois, DAS/UIUC has been granted permission to display these resources for educational purposes only, on a non-profit basis. Images may be viewed directly from the CD-ROM or the WW2010 web site (http://ww2010.atmos.uiuc.edu/). Credit is given to the resource owner in attached captions. Copyright is wholly retained by the owner. Please contact the copyright owners directly for any situation involving the use of images outside of the web server and this CD-ROM.
- **Teachers and Educators:** Permission is hereby granted to individual teachers to print out, copy and distribute the pages herein to their students for educational purposes.
- **Disclaimer:** No guarantee as to the availability or accuracy of the Weather World 2010 Current Weather Products, data, text, or links provided herein is implied. The user assumes all risk in deciding the suitability of these resources for any particular use.
- **Site Mirroring:** Mirroring of the Weather World 2010 Current Weather Products or any other resources on this server is not allowed without the explicit written permission from the developers at the University of Illinois.

For additional information contact: ww2010@atmos.uiuc.edu

CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

Hybrid Multimedia Educational CD-ROM

WW2010 (the weather world 2010 project)

The Weather World 2010 CD-ROM's are back!!!
If you would like to learn more about the CD-ROM, please read below. If you would like to order, click here for a printable order form.

The Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) would like to announce the release of the 2nd edition of the Weather World 2010 (WW2010) Educational CD-ROM. This resource is being constructed to provide local access to the high-graphics version our entire collection of Internet-based educational resources developed through our participation in NSF's Collaborative Visualization Project (CoVis). Most of these resources are currently available in the Online Guides.

New to the 2nd Edition of the WW2010 CD-ROM:
As seen on the web

- A Completely new Hurricane instructional module filled with new graphics and movies.
- New Modeling section to the Severe Storms instructional module including movies, animations, research results, and online access to streaming video.
- New pages in the Forces and Winds instructional module.
- Updates to the Satellite and Light & Optics instructional modules.
- New pages describing WW2010 Current weather products.
- Plus many other updates and revisions to other instructional modules

and background pages.

Features of the CD-ROM will include:

INSTRUCTIONAL MODULES - that use multimedia and the flexible nature of the web to enhance the impact of educational resources. These modules introduce and explain fundamental topics in Meteorology (Pressure, Severe Storms, El Niño, Forecasting etc.), Remote Sensing (Radars and Satellites) and how some of these aspects fit into the Hydrologic Cycle.
NOTE: The only resources found online and not on the CD-ROM are the Tropical Cyclone tracker and 3-D VRML Hurricane. They will still be accessible online from the CD-ROM.

ARCHIVED WEATHER DATA - and case studies of memorable weather events like Hurricane Andrew, Storm of the Century and the April 19, 1996 Illinois Tornado Outbreak. Each case contains relevant weather images, storm histories, photographs and eye-witness accounts.

STUDENT PROJECTS & ACTIVITIES - (complete with answer keys) that provide teachers with a meaningful way of integrating the data and instructional resources into the classroom.

REAL-TIME WEATHER DATA - will also be accessible from selected pages of the CD-ROM to allow the user to apply what they've learned to current weather conditions. These pages will link to relevant weather products accessible through our WW2010 web server.

EFFICIENT NAVIGATION - that allows users to move between hundreds of pages with only a few clicks and return easily.

These resources will be accessible from the CD-ROM by using any standard web browser and the interface will be nearly identical to their online counterparts. Therefore the same CD-ROM can be used on a Macintosh or an PC.

For a printable order form, click here!

If you have any questions or comments, please contact us at **ww2010@atmos.uiuc.edu**

Acknowledgments

developers

Daniel Bramer

Multimedia Specialist/Webmaster - Developed and edited instructional modules and diagrams. Responsible for editing "About WW2010" section including obtaining copyright permissions. Assisted System Manager in creating the final version of the Weather World 2010 Current Weather Products and the format and appearance adjustments to the WW2010 Educational CD-ROM.

David Wojtowicz

System Manager/Resource Programmer - Developed the underlying software infrastructure for the server including the AutoTree menu/navigation system. Maintains the machines that it runs on. Created and developed the Weather World 2010 Current Weather Products and their generation system.

Steven E. Hall

UIUC Covis Project Coordinator - Developed or edited instructional resources, text diagrams and curriculum. Responsible for web server layout and appearance, graphic design and the integration of the instructional resources into the new framework.

Principal Investigators

Bob Wilhelmson - Acting Department Head and Professor of Atmospheric Sciences.

Mohan Ramamurthy - Associate Professor of Atmospheric Sciences

---

Content Reviewers

DAS Students and Staff

Alex Brown - did the prototype design and HTML programming for constructing the text base navigation menus.

Bill Chapman - developed the early prototype of The Weather Visualizer

- a related product.

Paul Dekker - developed the original radar meteorology instructional module, graduated from this department in 1996.

Tom Grzelak - contributed to labeling of weather products and generation of multiple panel forecast images, received M.S. from this department in 1995.

Adam Houston - responsible for cover photograph for the CD-ROM.

Brian Jewett - took part in early developer meetings, developed several of the current weather products, developed simulations used in the Severe Storms instructional module.

Alan Liu - developed images for the El Niño instructional module, graduated from this department in 1997.

Geoff Manikin - constructed the Weather Forecasting instructional module, graduated from this department in 1995.

Norene McGhiey - transcribed text to the NOAA Severe Storms Spotters Guide, contributed to the April 19th Tornado Outbreak case study, and the Precipitation portion of the Clouds and Precipitation module.

Ed Mlodzik - constructed pages in the weather forecasting and midlatitude cyclones instructional modules, edited the Precipitation portion of the Clouds and Precipitation instructional module, took part in early developer meetings, helped prototype current weather products, graduated from this department in 1998.

Noah Nigg - developed the Virtual Reality Learning Tool for exploring hurricane Opal (VRML) for the Hurricane instructional Module

Scott Olthoff - constructed the Freezing Rain portion of the Clouds and Precipitation instructional module, prototyped current weather products, and took part in early developer meetings, graduated from this department in 1998.

Joel Plutchak - Java developer for current weather products, (e.g., The Interactive Weather Report and The Weather Visualizer), post-produced videos for the Hurricane instructional module.

Glen Romine - edited the Hurricanes instructional module.

Bruce Rose - constructed the Veteran's Day Snowstorm case study and took part in early developer meetings.

Crystal Shaw - helped with performance testing of WW2010, developed VRML scenes for the Severe Storms instructional module.

Yiqi Shao - constructed the Satellite Meteorology, El Niño, and the original Hurricanes instructional modules, plus the graphics design for a number of pages in the instructional modules.

Mythili Sridhar - constructed the original optics guide, the first online version of NOAA's Severe Storm Spotters Guide, graphically enhanced several modules, and prepared the CD-ROM for publication.

Ron Steve - constructed pages on the Forces and Winds instructional module, graduated from this department in 1996.

Vlad Tokarskiy - early Java developer (developed The Weather Animator) - a related product.

Jeff Van Dorn - constructed pages on the Air Masses and Fronts instructional module, responsible for cover photograph on 1st edition CD-ROM, graduated from this department in 1998.

Dave Werth - constructed pages on the Air Masses and Fronts instructional module, graduated from this department in 1997.

Kevin Wuebbles - helped transfer of old instructional modules to the new format.

About WW2010

content reviewers

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Welcome to the University of Illinois at Urbana-Champaign
Department of Atmospheric Sciences WWW site.

This site contains information about the academic program, research activities and faculty, staff and students of the Department. A listing of weather and internet resources are here to demonstrate our work.

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> To navigate this site , click on the menu items above. The current page is highlighted in yellow.

[Image: ww2010 home page image (60K)]

Go to our popular current weather products section. Just select 'current weather' from the menubar at left from any page to access them.

Our multimedia educational CD-ROM is **now available**.

Popular Features:

- Hurricanes
- Clouds and Precipitation
- El Niño

Developed by the Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC), WW2010 (the weather world 2010 project) is a WWW framework for integrating current and archived weather data with multimedia instructional resources using new and innovative technologies.

To ensure the greatest possible accuracy of our instructional resources, all materials have been reviewed and edited by professors and scientists from the Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) and the Illinois State Water Survey.

WW2010
09/02/99

Online Guides
Collection of multimedia instructional modules in meteorology and remote sensing, plus curriculum projects and classroom activities.

Archives
Data and descriptions for memorable weather events.

WW2010 Educational CD-ROM
Details and ordering information about our hybrid multimedia educational CD-ROM.

About WW2010
Details about the features, philosophies and personnel responsible for WW2010.

Current Weather
Contains current weather information for the surface, upper air, as well as satellite products.

This is a work-in-progress, so we will release sections as they are completed. To access a low graphics version of this server, click the "text" option in the blue User Interface menu (left).

This web server is a result of cooperation amongst personnel in the Department of Atmospheric Sciences at the University of Illinois at Urbana-Champaign, the Collaborative Visualization Project (CoVis), the Horizon Project, and NCSA. The Collaborative Visualization Project was funded by the National Science Foundation under NSF grant RED-9454729, while the Horizon project was funded by NASA CAN Project Test Applications and Digital Library Technologies in Support of Public Access to Earth and Space Science Data, Grant Number NCC-5-106.

Terms for using data resources. CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

Online Guides

Urbana, Illinois Tornado

nexrad close-ups

[Image: urbana hook echo (26K)]

8:24pm CDT (4/19/96) - The Champaign sirens had been activated. The ILX reflectivity panel at the time indicated a pair of hook echoes attached to supercells moving through East-Central Illinois.

[Image: urbana velocity couplets (23K)]

Multiple mesocyclones were passing through the Champaign/Urbana area.

---

monticello

ogden

urbana
ogden

User Interface

graphics text

[Image: CD-ROM logo (73K)]

NEW! Online ordering is now available!

The Weather World 2010 CD-ROM's are back!!!
If you would like to learn more about the CD-ROM, please read below. If you would like to order, either click here to order online by credit card or click here for a printable order form.

The Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) would like to announce the release of the 2nd edition of the Weather World 2010 (WW2010) Educational CD-ROM. This resource is being constructed to provide local access to the high-graphics version our entire collection of Internet-based educational resources developed through our participation in NSF's Collaborative Visualization Project (CoVis). Most of these resources are currently available in the Online Guides.

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NOTE: The only resources found online and not on the CD-ROM are the Tropical Cyclone tracker and 3-D VRML Hurricane. They will still be accessible online from the CD-ROM.

ARCHIVED WEATHER DATA - and case studies of memorable weather events like Hurricane Andrew, Storm of the Century and the April 19, 1996 Illinois Tornado Outbreak. Each case contains relevant weather images, storm histories, photographs and eye-witness accounts.

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Click here to order online with a credit card or for other payment options using a printable order form, click here!

If you have any questions or comments, please contact us at **ww2010@atmos.uiuc.edu**

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satellite images

Current Weather

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Continental U.S.	Continental U.S.
Atlantic	Atlantic
Pacific	Pacific

Visible	**Water Vapor**
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Continental U.S.	Continental U.S.
Atlantic	Atlantic
Pacific	Pacific

Composite Images

Infrared Satellite / Sea Level Pressure

Infrared Satellite / Sea Level Pressure / Wind Vectors

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surface

radar

April 19th Tornado Outbreak

contributors to case study development

Below is a list of those who contributed to the development of the April 19th Tornado Outbreak case study in the WW2010 Case Study Archive. We greatly appreciate the efforts of those who contributed to the development of this case study.

WW2010 Personnel:
Steven E. Hall - Developer and Content Editor - Developed original-version of this online case study. Responsible for new layout, organization, cross linking of helper pages and construction of animations. Implemented text and graphics modifications as recommended by the Content Reviewers.

Bruce Lee - Content Reviewer - Edited module text and diagrams for scientific accuracy. Also provided narrative text for images captured from the chase.

Brian Jewett - Data Management - Collected and archived all weather data that is accessible from this case study.

Selected Images and Photographs:
For resources not developed by the University of Illinois, DAS/UIUC has been granted permission to display these resources for educational purposes only, on a non-profit basis. Images may be viewed directly from the CD-ROM or the WW2010 web site (http://ww2010.atmos.uiuc.edu/). Credit is given to the resource owner in attached captions. Copyright is wholly retained by the owner. Please contact the copyright owners directly for any situation involving the use of images outside of the web server and this CD-ROM. We would like to thank the following for permission to use their photographs and images in the WW2010 web server.

Video footage and stills from storm chase:
Tom Grzelak, Tim Shy, Brian Jewett, Gwen Jewett, and Bruce Lee.

Damage photographs from Ogden, IL:
Norene McGhiey - mcghiey@atmos.uiuc.edu

Storm Interceptor Team Members:
Bruce Lee - Team Leader
Brian Jewett - Team Leader
Gwen Jewett

veteran's day snow

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graphicstext

Tim Shy
Tom Grzelak

Remote Sensing

hurricane andrew

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no words starting with this letter

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[Image: online guides image menu (76K)]
Graphic by: Steven E. Hall

Welcome to the WW2010 Online Guides, the next evolution phase of our web-based instructional resources. Formerly known as the Guide to Meteorology, we are expanding these resources beyond the scope of meteorology to other disciplines like climate, remote sensing and global change. We will attempt to present these topics not as individual sciences, but as integral components of a much larger system, learning about the planet on which we live. Available Online Guides include:

Guides

Last Update: 09/02/99

Meteorology
Instructional modules that introduce topics in meteorology from fronts to El Niño.

Remote Sensing
Instructional modules that introduce remote sensing technologies and their applications in meteorology.

Reading and Interpreting Weather Maps
Instructional resources that provide valuable information for the correct interpretation of weather products accessible (or soon to be accessible) from WW2010.

Projects & Activities
Curriculum aids that provide teachers with a blueprint for integrating web-based educational resources into the classroom.

The Online Guides use multimedia technology and the dynamic capabilities of the web. These resources incorporate text, colorful diagrams, animations, computer simulations, audio and video to introduce topics and concepts for a wide variety of disciplines. Selected pages link to (or will soon link to) current weather products, allowing the user to apply what the user has learned to real-time weather data. The Online Guides are an important component of the WW2010 Hybrid Multimedia Environment. Not only are they a part of this web server, but they are also (or will soon be) available for local access via educational CD-ROM.

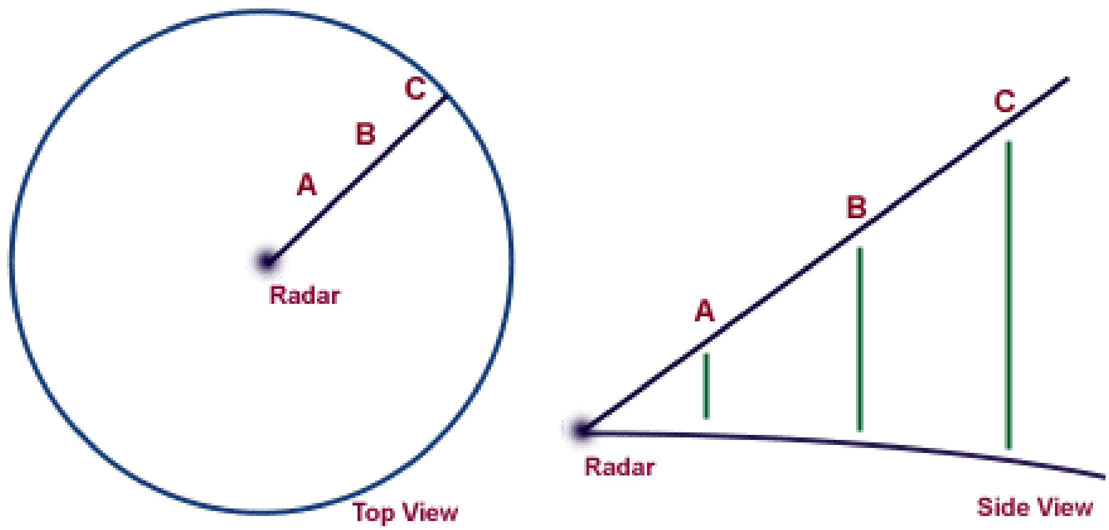
The target audience for the Online Guides is high school and undergraduate level students. However, these resources have been used by instructors throughout K-12, undergraduate and graduate level education. Contents of the Online Guides were developed by graduate students and faculty through our efforts in the Collaborative Visualization Project (CoVis), which was funded by the National Science Foundation. These resources have been reviewed by faculty and scientists at the University of Illinois and the Illinois State Water Survey. Many of these resources were tested in a classroom environment and have been modified based upon teacher and student feedback.

The navigation menu (left) for this resource is called "Online Guides" and the available guides are listed as menu items, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Interpreting Doppler Radar Velocities

speed shear wind patterns

To understand Doppler radial velocity patterns, one first has to consider the geometry of a radar scan. Normally the radar beam is pointed at an elevation angle greater than zero so that the beam, as it moves away from the radar, moves higher and higher above the surface of the earth. Because of this geometry, radar returns originating from targets near the radar represent the low-level wind field, while returns from distant targets represent the wind field at higher levels.



On a radar PPI display, the distance away from the radar at the center of the display represents both a change in horizontal distance and a change in vertical distance. To determine the wind field at a particular elevation above the radar, one must examine the radial velocities on a ring at a fixed distance from the radar. The exact elevation represented by a particular ring depends upon the elevation angle of the radar beam.

In the examples below, idealized Doppler radial velocity patterns were constructed with a computer assuming simple vertical wind field patterns. These simplified radial velocity patterns can help us understand the more complicated patterns that are associated with storm motions. Doppler velocity patterns (right) correspond to vertical wind profiles (left), where the wind barbs indicate wind speed and direction from the ground up to 24,000 feet. Negative Doppler velocities (blue-green) are toward the radar and positive (yellow-red) are away. The radar location is at the center of the display.

[Image: wind direction constant with height (35K)]

Image by: Brown & Wood

For this first example, wind direction is constant with height, but wind speed increases from 20 knots at the ground to 40 knots at 24,000 feet. Note on the

graphicstext

radial velocity field that the maximum inbound velocity is to the west and maximum outbound to the east while to the north and south the radar measures zero radial velocity. This is because the winds are perpendicular to the radar beam when viewed to the north or south.

[Image: maximum speed at mid levels (32K)]

Image by: Brown & Wood

In the second example, the winds increase from 20 to 40 knots between zero and 12,000 feet and then decrease again to 20 knots at 24,000 feet. The wind direction again is constant. The radar beam intersects the 12,000 foot level along a ring half-way across the radar display. This is where we see the maximum inbound and outbound velocities.

[Image: difluent wind flow (29K)]

Image by: Brown & Wood

In the third example, we see a wind field which changes direction from north to south but has a constant speed at all heights. The zero radial velocity line now bends so that it is everywhere perpendicular to the wind field. The maximum radial velocities are observed where the radar beam points directly toward or away from the wind direction.

[Image: confluent wind flow (30K)]

Image by: Brown & Wood

In our fourth example, we see the same effect but in this case, the flow is confluent instead of difluent.

Imagery

directional shear

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Units of Temperature

from fahrenheit to celsius to kelvin and back

Degrees **Fahrenheit**, (developed in the early 1700's by G. Daniel Fahrenheit), are used to record surface temperature measurements by meteorologists in the United States. However, since most of the rest of the world uses degrees **Celsius** (developed in the 18th Century), it is important to be able to convert from units of degrees Fahrenheit to degrees Celsius:

Fahrenheit to Celsius:

$$^{\circ}C = (^{\circ}F - 32) / 1.8$$

Kelvin is another unit of temperature that is very handy for many scientific calculations, since it begins at **absolute zero**, meaning it has no negative numbers. (Note...the word "degrees" is NOT used with Kelvin.) The way to convert from degrees Celsius to Kelvin is:

[Image:]

The three different temperature scales have been placed side-by-side in the chart below for comparison.

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Temperature Scales

Fahrenheit	Celsius	Kelvin	
212	100	373	Boiling point of water at sea-level
194	90	363	
176	80	353	
158	70	343	
140	60	333	
122	50	323	
104	40	313	
86	30	303	
68	20	293	Average room temperature
50	10	283	
32	0	273	Melting (freezing) point of ice (water) at sea-level
14	-10	263	
-4	-20	253	
-22	-30	243	
-40	-40	233	
-58	-50	223	
-76	-60	213	
-94	-70	203	
-112	-80	193	-89°C (-129 °F) Lowest recorded temperature. Vostok, Antarctica July, 1983
-130	-90	183	
-148	-100	173	

Reference: Ahrens (1994)

Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign

Image adapted from: Ahrens

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[Image: curriculum image menu (72K)]

Welcome to the first collection of CoVis-WW2010 student projects and activities in the atmospheric sciences. These resources were developed through our participation in NSF's Collaborative Visualization (CoVis) project which supports project-based learning of the sciences for grade levels 9-12. These resources have already been implemented in a number of CoVis classrooms and have been modified based upon student and teacher feedback. The Projects and Activities have been organized into the following secitions.

Activities

Last Update: 08/01/97

Open-Ended Projects
Two units: case study of a winter storm and learning how to forecast.

Classroom Activities
Short, structured activities on a variety of topics in meteorology.

Teacher Guides
Assessment tools for teachers.

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The materials have been broken down into four primary groups. Open-Ended Projects involve working with real-time and archived weather data to solve a specific problem. Classroom Activities provide a structured environment for learning about a variety of topics in meteorology. These activities may require up to 90 minutes of classtime to complete. Teacher guides for each activity have also been provided.

The navigation menu (left) for this module is called "Online Curriculum" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Upper Air Obs

Open-Ended Projects

[Image: home image (62K)]
Graphic by: Steven E. Hall

The Online Meteorology Guide is a collection of web-based instructional modules that use multimedia technology and the dynamic capabilities of the web. These resources incorporate text, colorful diagrams, animations, computer simulations, audio and video to introduce fundamental concepts in the atmospheric sciences. Selected pages link to (or will soon link to) relevant classroom activities and current weather products to reinforce topics discussed in the modules and allow the user to apply what has been learned to real-time weather data. Available modules include:

Modules

Last Update: 09/02/99

Light and Optics
The interaction between light and atmospheric particles and the colorful optical effects that result.

Clouds and Precipitation
Cloud classifications and the processes by which clouds and precipitation develop.

Forces and Winds
Forces that influence the flow of air and how they interact to produce wind.

Air Masses and Fronts
The most common types of air masses and fronts, plus a look at the different types of advection.

Weather Forecasting
General forecasting methods, important surface features, plus forecasting tips for different scenarios.

Severe Storms
The online version of NOAA's Severe Storm Spotters Guide. Investigates the different types of thunderstorms, their associated components, plus an in depth look at tornadoes.

Hurricanes
The anatomy of hurricanes, how they develop and why they are so dangerous.

El Niño
Why El Niño develops and the global impact it has on weather patterns and economics.

Hydrologic Cycle

The circulation and conservation of the earth's water.

The target audience for the Online Meteorology Guide is high school and undergraduate level students. However, these resources have been used by instructors throughout K-12, undergraduate and graduate level education. Contents of the Online Meteorology Guide were developed by graduate students and faculty through our efforts in the Collaborative Visualization Project (CoVis), which was funded by the National Science Foundation. These resources have been reviewed by faculty and scientists at the University of Illinois and the Illinois State Water Survey. Many of these resources were tested in a classroom environment and have been modified based upon teacher and student feedback.

The navigation menu (left) for this module is called "Meteorology" and the available modules are listed as menu items, beginning with this introduction. Click on the menu item of interest to go to that particular module. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

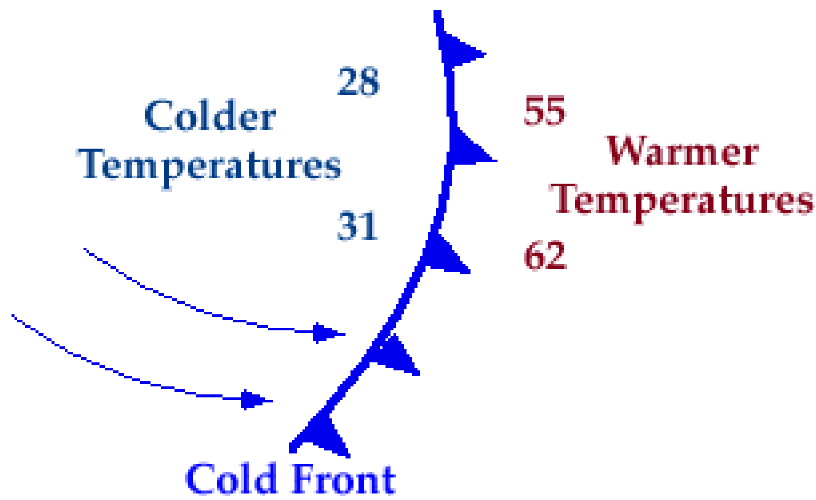
Online Guides

Air Masses, Fronts

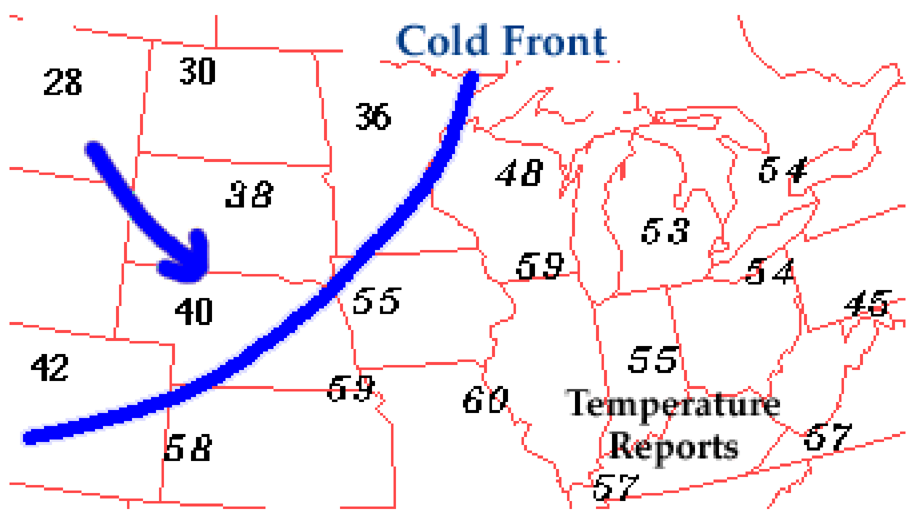
Cold Front

transition zone from warm air to cold air

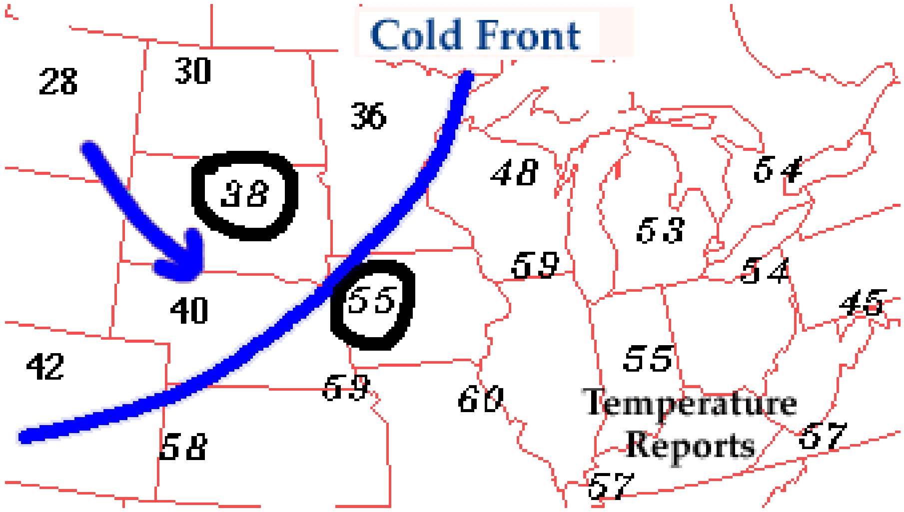
A cold front is defined as the transition zone where a cold air mass is replacing a warmer air mass. Cold fronts generally move from northwest to southeast. The air behind a cold front is noticeably colder and drier than the air ahead of it. When a cold front passes through, temperatures can drop more than 15 degrees within the first hour.



Symbolically, a cold front is represented by a solid line with triangles along the front pointing towards the warmer air and in the direction of movement. On colored weather maps, a cold front is drawn with a solid blue line.



There is typically a noticeable temperature change from one side of a cold front to the other. In the map of surface temperatures below, the station east of the front reported a temperature of 55 degrees Fahrenheit while a short distance behind the front, the temperature decreased to 38 degrees. An abrupt temperature change over a short distance is a good indicator that a front is located somewhere in between.



If colder air is replacing warmer air, then the front should be analyzed as a cold front. On the other hand, if warmer air is replacing cold air, then the front should be analyzed as a warm front. Common characteristics associated with cold fronts have been listed in the table below.

	Before Passing	While Passing	After Passing
Winds	south-southwest	gusty; shifting	west-northwest
Temperature	warm	sudden drop	steadily dropping
Pressure	falling steadily	minimum, then sharp rise	rising steadily
Clouds	increasing: Ci, Cs and Cb	Cb	Cu
Precipitation	short period of showers	heavy rains, sometimes with hail, thunder and lightning	showers then clearing
Visibility	fair to poor in haze	poor, followed by improving	good, except in showers
Dew Point	high; remains steady	sharp drop	lowering

Table adapted from: Ahrens, (1994)

Fronts

wind shift

El Niño

a warm current of water

El Niño (Spanish name for the male child), initially referred to a weak, warm current appearing annually around Christmas time along the coast of Ecuador and Peru and lasting only a few weeks to a month or more. Every three to seven years, an El Niño event may last for many months, having significant economic and atmospheric consequences worldwide. During the past forty years, ten of these major El Niño events have been recorded, the worst of which occurred in 1997-1998. Previous to this, the El Niño event in 1982-1983 was the strongest. Some of the El Niño events have persisted more than one year.

El Niño Years			
1902-1903	1905-1906	1911-1912	1914-1915
1918-1919	1923-1924	1925-1926	1930-1931
1932-1933	1939-1940	1941-1942	1951-1952
1953-1954	1957-1958	1965-1966	1969-1970
1972-1973	1976-1977	1982-1983	1986-1987
1991-1992	1994-1995	1997-1998	

Selected text from: CPC ENSO Main Page

In the tropical Pacific, trade winds generally drive the surface waters westward. The surface water becomes progressively warmer going westward because of its longer exposure to solar heating. El Niño is observed when the easterly trade winds weaken, allowing warmer waters of the western Pacific to migrate eastward and eventually reach the South American Coast (shown in orange). The cool nutrient-rich sea water normally found along the coast of Peru is replaced by warmer water depleted of nutrients, resulting in a dramatic reduction in marine fish and plant life.

[Image: animation of El Niño current (77K)]

Animation by: Shao

In contrast to El Niño, La Niña (female child) refers to an anomaly of unusually cold sea surface temperatures found in the eastern tropical Pacific. La Niña occurs roughly half as often as El Niño.

La Niña Years			
1904-1905	1909-1910	1910-1911	1915-1916
1917-1918	1924-1925	1928-1929	1938-1939

non el nino years
el nino events
sea surface temps
impacts on weather
economic impacts
prediction

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1950-1951	**1955-1956**	**1956-1957**	**1964-1965**
1970-1971	**1971-1972**	**1973-1974**	**1975-1976**
1988-1989	**1995-1996**		

Selected text from: CPC ENSO Main Page

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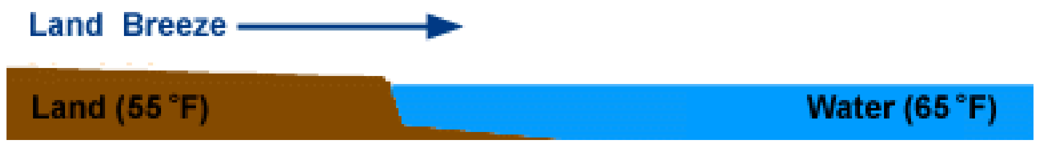
introduction

'97-'98 event

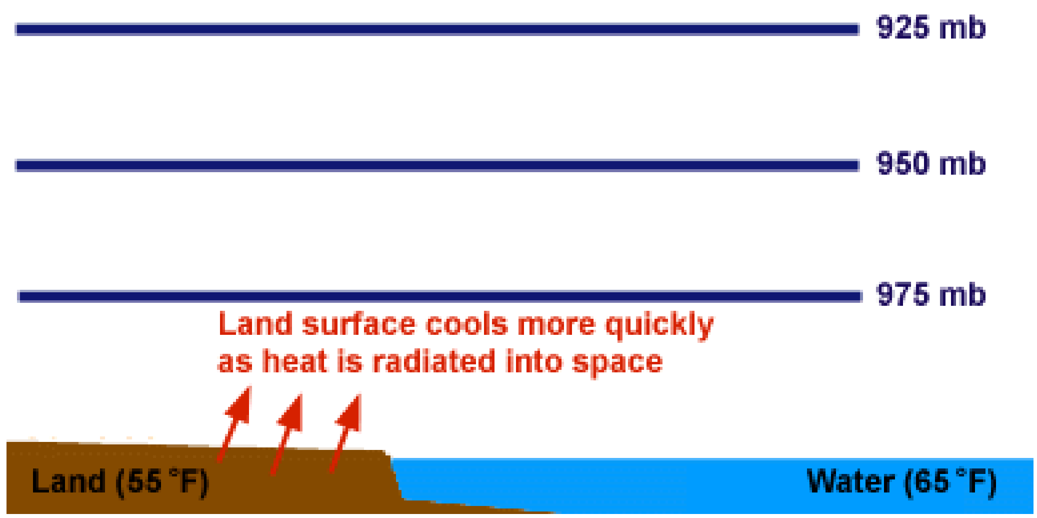
Land Breezes

begin with the cooling of low-level air

On clear, calm evenings, temperature differences between a body of water and neighboring land produce a cool wind that blows offshore. This wind is called a "land breeze". Land breezes are strongest along the immediate coastline but weaken considerably further inland.



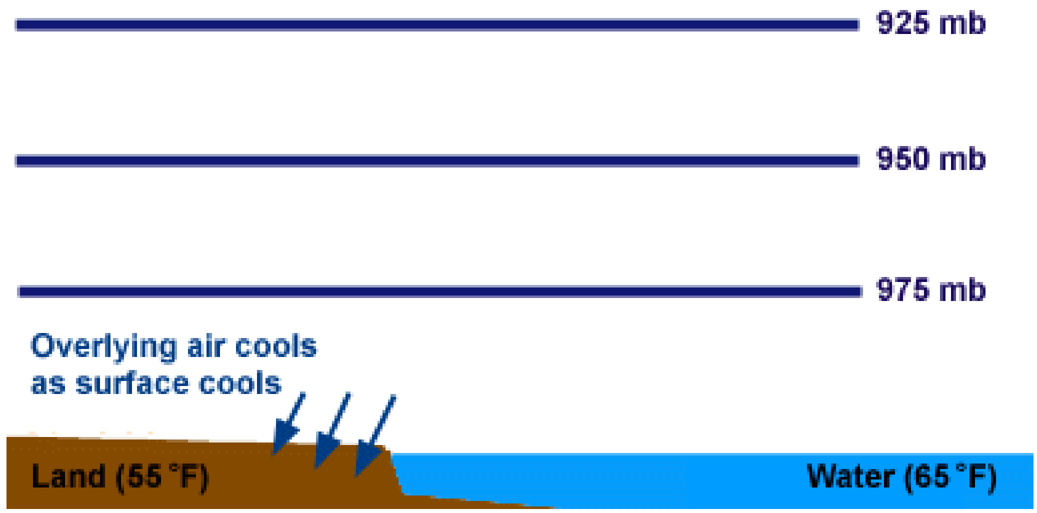
Land-breeze circulations can occur at any time of year, but are most common during the fall and winter seasons when water temperatures are still fairly warm and nights are cool.



- On clear and calm evenings, the earth's surface cools by radiating (giving off) heat back into space, and this results in a cooling of the immediately overlying air.

Land Breezes

User Interface



Since the air over land cools more rapidly than the air over water, a temperature difference is established, with cooler air present over land and relatively warmer air located over water.

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

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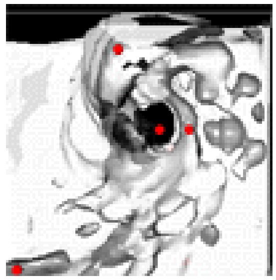
movement

[Image: hurricane logo (446K)]

Graphic by: Dan Bramer



Fly through a 3-D Hurricane!
added (1/08/1999)

Requires a VRML player/plugin. See bottom of page for a recommended one.

Interact with Atlantic hurricanes from 1950-2003!!

Hurricanes are cyclones that develop over the warm tropical oceans and have sustained winds in excess of 64 knots (74 miles/hour). These storms are capable of producing dangerous winds, torrential rains and flooding, all of which may result in tremendous property damage and loss of life in coastal populations. One memorable storm was Hurricane Andrew (pictured above), which was responsible for at least 50 deaths and more than $30 billion in property damage. The purpose of this module is to introduce hurricanes and their associated features, to show where hurricanes develop, and to explain the atmospheric conditions necessary for hurricane development. The Hurricane module has been organized into the following sections:

Sections

Last Update: 09/16/99

Definition and Growth
Defines a hurricane and shows the regions and mechanics of hurricane development.

Stages of Development
The different stages of development from depression to hurricane.

Structure of a Hurricane
Discusses the structure of different parts of hurricanes.

Explore a 3-D Hurricane
View a hurricane in a 3 dimensional VRML world generated by a computer model. Requires a VRML player/plugin. See bottom of page for a recommended one.

Movement
The influence of global winds on the movement of hurricanes.

Satellites and Hurricane Hunters
Discusses the tools and means meteorologists use to observe and track hurricanes.

Preparations
Includes a list of matters to consider if you are threatened by a hurricane.

Damage and Destruction
Destructive features associated with hurricanes, plus the Saffir-Simpson Scale for classifying damage potential.

Hurricane Tracks
Track Atlantic Hurricanes interactively from 1950 to 2003.

User Interface

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How They Are Named

The different names given to hurricane-like storms in different parts of the world.

Global Activity

Discusses the regions of the Earth where tropical cyclones can be found.

El Niño

See how El Niño appears to affect hurricane activity.

Acknowledgments

Those who contributed to the development of this module.

The navigation menu (left) for this module is called "Hurricanes" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Recommended VRML plugin:

Land Breezes

Growth Processes

Convergence Associated With Cyclones

extra-tropical and tropical cyclones

Both extra-tropical and tropical cyclones, like this hurricane, can cause air to rise. This type of lifting is different from the lifting produced along frontal boundaries.

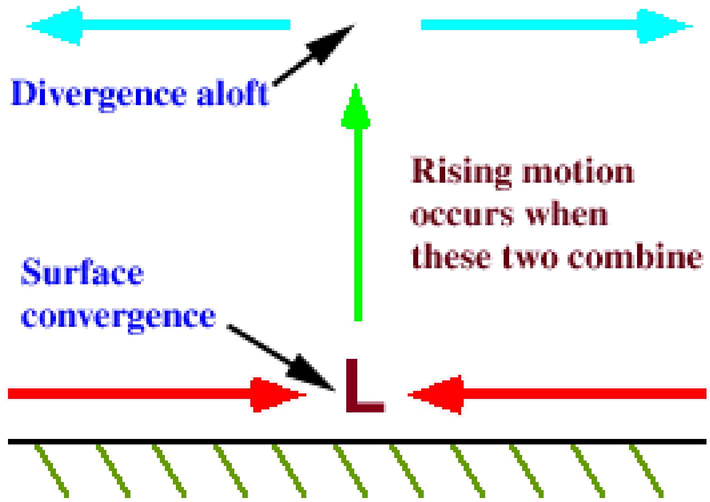
[Image: hurricane picture (68K)]
Image by: the GOES Project

In hurricanes, condensation occurs through a process known as CISK (Convective Instability of the Second Kind). We will demonstrate CISK by referring to the animated cross-section through a mature hurricane given below. In CISK, surface convergence (pink horizontal arrows) causes rising motion around a surface cyclone (labeled as "L"). The air cools as it rises (red vertical arrows) and condensation occurs, which releases latent heat into the atmosphere. This heating causes air to expand, creating an area of high pressure aloft. The force resulting from the established pressure gradient causes air to diverge at upper levels (red horizontal arrows).

[Image: hurricane (25K)]
Animation by: Shao

Since pressure is a measure of the weight of the air above a unit area, removal of air at upper levels subsequently reduces pressure at the surface. A further reduction in surface pressure leads to increasing convergence (due to an intensified pressure gradient), which further intensifies the rising motion, latent heat release, and so on. Despite the absence of fronts, a tremendous amount of lifting occurs in hurricanes, with intense condensation leading to the development of deep clouds and heavy rainfall.

In extra-tropical cyclones, surface winds are deflected by friction towards the center of the low pressure system (red "L" below).



Coupled with divergence aloft, (blue arrows), surface convergence (red arrows) can generate rising motion (green arrow) that leads to the condensation of water vapor.

---

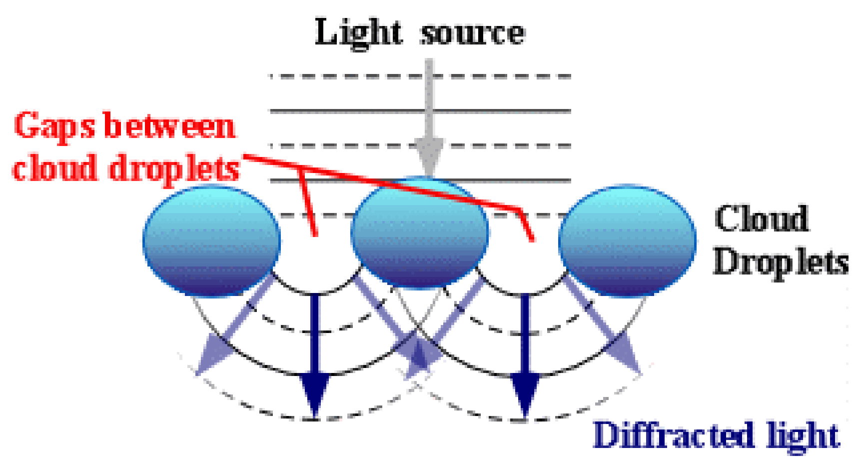
convection

fronts

Diffraction of Light

light bending around an object

Diffraction is the slight bending of light as it passes around the edge of an object. The amount of bending depends on the relative size of the wavelength of light to the size of the opening. If the opening is much larger than the light's wavelength, the bending will be almost unnoticeable. However, if the two are closer in size or equal, the amount of bending is considerable, and easily seen with the naked eye.



In the atmosphere, diffracted light is actually bent around atmospheric particles -- most commonly, the atmospheric particles are tiny water droplets found in clouds. Diffracted light can produce fringes of light, dark or colored bands. An optical effect that results from the diffraction of light is the silver lining sometimes found around the edges of clouds or coronas surrounding the sun or moon. The illustration above shows how light (from either the sun or the moon) is bent around small droplets in the cloud.

Optical effects resulting from diffraction are produced through the interference of light waves. To visualize this, imagine light waves as water waves. If water waves were incident upon a float residing on the water surface, the float would bounce up and down in response to the incident waves, producing waves of its own. As these waves spread outward in all directions from the float, they interact with other water waves. If the crests of two waves combine, an amplified wave is produced (constructive interference). However, if a crest of one wave and a trough of another wave combine, they cancel each other out to produce no vertical displacement (destructive interference).

water droplets

mechanisms

reflection
scattering
refraction
diffraction

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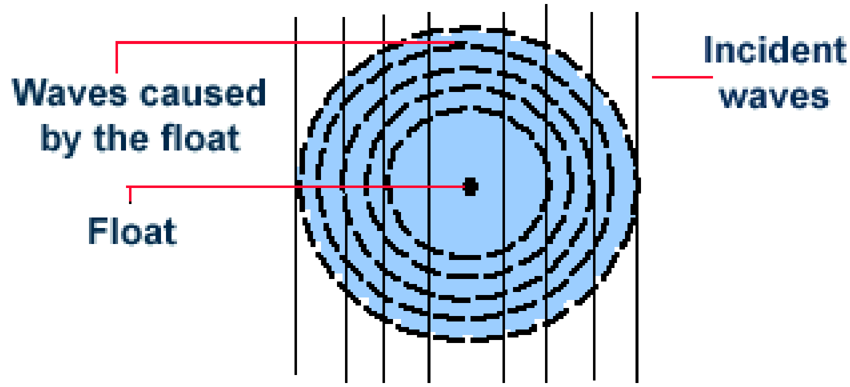

This concept also applies to light waves. When sunlight (or moonlight) encounters a cloud droplet, light waves are altered and interact with one another in a similar manner as the water waves described above. If there is constructive interference, (the crests of two light waves combining), the light will appear brighter. If there is destructive interference, (the trough of one light wave meeting the crest of another), the light will either appear darker or disappear entirely.

Refraction

air, dust, haze

Midlatitude Cyclones

bringing weather change

[Image: home image (68K)]

Graphic by: Ed Mlodzik

Midlatitude cyclones are the cause of most of the stormy weather in the United States, espeically during the winter season. Understanding the structure and evolution of midlatitude cyclones is crucial for predicting significant weather phenomena such as blizzards, flooding rains, and severe weather.

A midlatitude cyclone is an area of low pressure located between 30 degrees and 60 degrees latitude. Since the continental United States is located in this latitude belt, these cyclones impact the weather in the U.S.

This instructional module introduces the most important features of midlatitude cyclones. The module is divided into the following sections:

Sections

Last Update: 08/22/97

Definition of a Cyclone
The general structure of a cyclone and associated air masses and fronts is discussed.

Winds Associated With a Cyclone
A cyclone can be located simply using the wind barbs.

Air Masses and Cyclones
The movement of air masses associated with cyclone is discussed.

Cyclones on Satellite Images
A midlatitude cyclone looks very distinct on a satellite image.

Upper Air Features
Cyclones develop as a result of upper air features discussed in this section, included troughs, wave amplification, and jet streaks.

Acknowledgements
Those who contributed to the development of this module.

The navigation menu (left) for this module is called "Midlatitude Cyclones" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface

air masses
on satellite images
upper air features

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graphics text

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Rainbows

definition

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dangers of t-storms
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tstorm components

A Developing Supercell Intensifies

precipitation and winds intensify, rotation develops

This was initially a small supercell, looking west from about 8 miles, that packed a very intense rotating updraft. The rain curtains extending beneath the storm base were rotating, and looked very much like the rain areas we have seen under HP supercell bases. Once again, note the vaulted appearance on the north (right) side of the updraft. The storm was producing baseball size hail at this time, and a low-pitched, subtle, and continuous roaring sound was heard. Storm chasers have heard this a number of times, particularly close to LP storms, and attribute it to hailfall.

[Image: hail producing storm (59K)]

Photograph by: Moller

Below is a northward view of the storm's main precipitation area. It has the nearly transparent look of an LP storm. The radar echo at this time showed a relatively small VIP 4 storm, although a small radar pendant was present. A VIP 4 with baseball hail! Indeed, it seemed to have mainly LP characteristics, except for the rotating rain curtains wrapping around the updraft base.

[Image: evolved into an lp storm (56K)]

Photograph by: Moller

At this time and location, just west of Archer City, Texas, east surface winds were blowing into the supercell at 25 to 30 MPH. We are very close in position to the pseudo-warm front, separating cool outflow coming from this precipitation area to the north from warm air to the south...

Tornadoes

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
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modeling

Tornadoes

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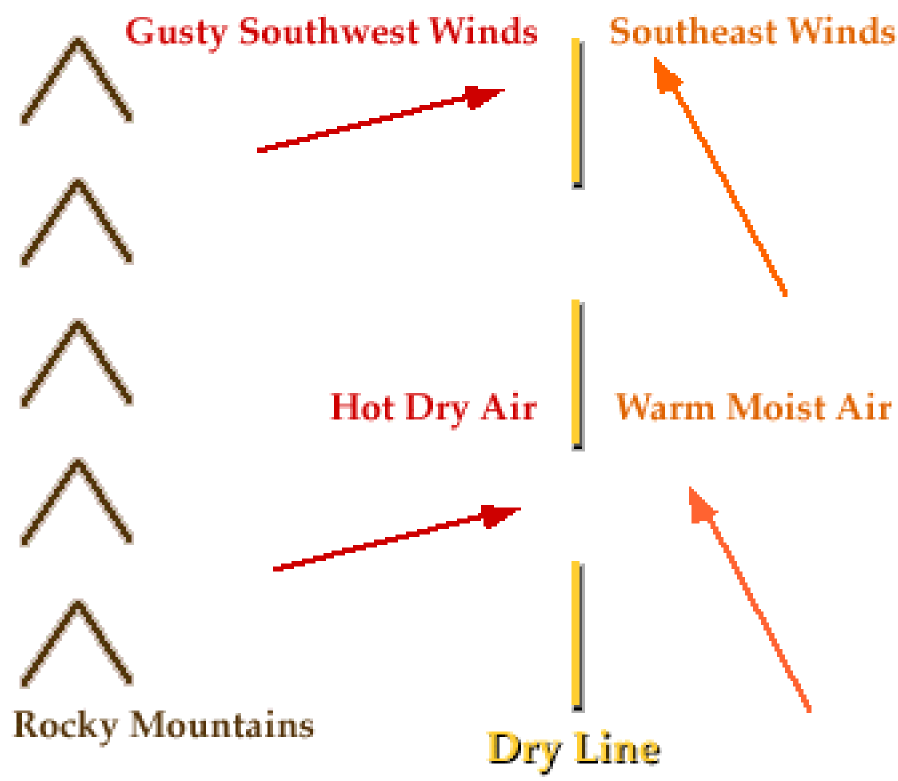
Dry Line

a moisture boundary

Forecast Tip:
If a dryline is approaching your region, predict that air will be much drier after the boundary moves through. Storms are possible as the dryline approaches. The temperature may rise after the dryline passes through, since dry air heats up more quickly than moist air.

A dryline is a boundary that separates a moist air mass from a dry air mass. A dryline is also called a **Dew Point Front**. Sharp changes in dew point temperature can be found across a dryline (sometimes 9 degrees **Celsius** per kilometer). Drylines are most commonly found just east of the Rocky Mountains, separating a warm, moist air mass to the east from a hot, dry air mass to the west (see diagram below).



States like Texas, New Mexico, Oklahoma, Kansas, and Nebraska frequently experience drylines in the spring and summer, while east of the Mississippi River, drylines are extremely rare. The dryline is represented on surface maps by a dashed yellow line (see example below).

[Image: dry line on weather map (24K)]

Dew points east of the dryline shown above range from the upper 50's to low 70's, with winds from the southeast. West of the dryline, dew points are much lower, in the 20's and 30's, which is almost 50 degrees less than those found east of the dryline.

Air temperature ahead of the dryline is generally in the 70's and 80's. Behind the dryline, temperatures are hotter, ranging from the mid 80's to mid 90's. The drier air behind the dryline lifts the moist air ahead of it as it advances, which could lead to the development of thunderstorms along and ahead of the dryline in a manner similar to how thunderstorms develop along cold fronts.

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occluded fronts

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Temperatures

Relative Humidity

indicates how moist the air is

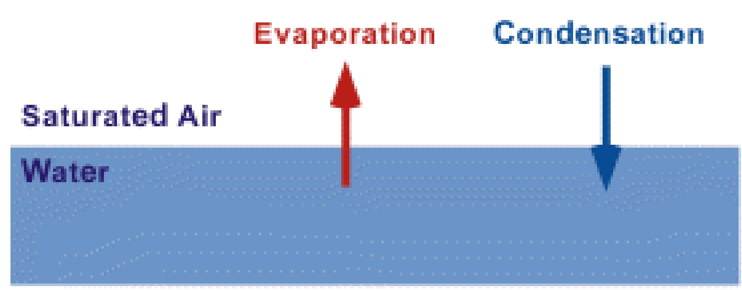
Relative humidity may be defined as the ratio of the water vapor density (mass per unit volume) to the saturation water vapor density, usually expressed in percent:

$$\textbf{Relative Humidity (RH)} = \frac{\text{(Actual Vapor Density)}}{\text{(Saturation Vapor Density)}} \times 100\%$$

Relative humidity is also approximately the ratio of the actual to the saturation vapor pressure.

$$\textbf{RH} = \frac{\text{(Actual Vapor Pressure)}}{\text{(Saturation Vapor Pressure)}} \times 100\%$$

Actual vapor pressure is a measurement of the amount of water vapor in a volume of air and increases as the amount of water vapor increases. Air that attains its saturation vapor pressure has established an equilibrium with a flat surface of water. That means, an equal number of water molecules are evaporating from the surface of the water into the air as are condensing from the air back into the water.



Saturation vapor pressure is a unique function of temperature as given in the table below. Each temperature in the table may be interpreted as a dew point temperature, because as the ground cools, dew will begin to form at the temperature corresponding to the vapor pressure in this table.

(C) Temp (F)	Sat Vapor Prs (mb)	(C) Temp (F)	Sat Vapor Prs (mb)

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-18	00	1.5	|	18	65	21.0
-15	05	1.9	|	21	70	25.0
-12	10	2.4	|	24	75	29.6
-09	15	3.0	|	27	80	35.0
-07	20	3.7	|	29	85	41.0
-04	25	4.6	|	32	90	48.1
-01	30	5.6	|	35	95	56.2
02	35	6.9	|	38	100	65.6
04	40	8.4	|	41	105	76.2
07	45	10.2	|	43	110	87.8
10	50	12.3	|	46	115	101.4
13	55	14.8	|	49	120	116.8
16	60	17.7	|	52	125	134.2

Chart adapted from: Ahrens

For example, if the water vapor pressure in the air is 10.2 millibars (mb), dew will form when the ground reaches 45 degrees Fahrenheit (F). The relative humidity for air containing 10.2 mb of water vapor is simply 100% times 10.2 mb divided by the saturation vapor pressure at the actual temperature. For example, at 70 F the saturation vapor pressure is 25 mb, so the relative humidity would be

RH = 100% X (10.21 / 25.0) = 41%

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states of water

rising air

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Cirrus Clouds

thin and wispy

The most common form of high-level clouds are thin and often wispy cirrus clouds. Typically found at heights greater than 20,000 feet (6,000 meters), cirrus clouds are composed of ice crystals that originate from the freezing of supercooled water droplets. Cirrus generally occur in fair weather and point in the direction of air movement at their elevation.

[Image: more cirrus clouds (76K)]

Cirrus can form from almost any cloud that has undergone glaciation and can be observed in a variety of shapes and sizes. Possibilities range from the "finger-like" appearance of cirrus fall streaks to the uniform texture of more extensive cirrus clouds associated with an approaching warm front.

[Image: cirrus fall streaks (83K)]

Photograph by: Holle

Fall streaks form when snowflakes and ice crystals fall from cirrus clouds. The change in wind with height and how quickly these ice crystals fall determine the shapes and sizes the fall streaks attain. Since ice crystals fall much more slowly than raindrops, fall streaks tend to be stretched out horizontally as well as vertically. Cirrus streaks may be nearly straight, shaped like a comma, or seemingly all tangled together.

Similar to fall streaks is virga, which appears as streamers suspended in the air beneath the base of precipitating clouds. Virga develops when precipitation falls through a layer of dry air and evaporates before reaching the ground.

Cloud Types

cirrostratus

precipitation

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High-Level Clouds

cirrus
cirrostratus

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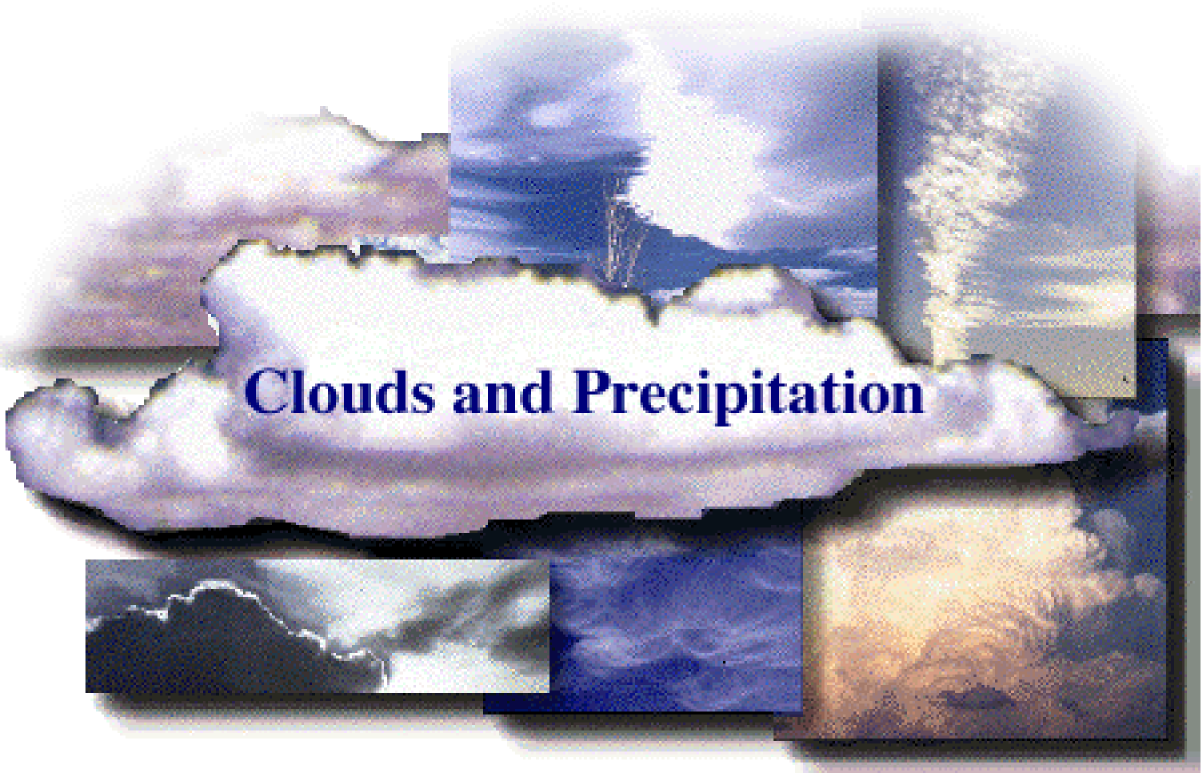
Clouds and Precipitation

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Clouds and Precipitation

contributors to module development

WW2010 Personnel (Clouds):
Steven E. Hall - Content Developer and Editor - Scanned in slides, constructed original text and diagrams. Responsible for new layout, organization and cross linking of helper pages. Implemented text and graphics modifications as recommended by the Content Reviewers.

John Walsh - Content Reviewer - Professor of Atmospheric Sciences who edited module text and diagrams for scientific accuracy.

Ken Beard - Content Reviewer - Professor of Atmospheric Sciences who edited module text and diagrams for scientific accuracy.

Mythili Sridhar - Graphics Assistant- Graphically enhanced previous version of this module.

Yiqi Shao - HTML Programmer and Graphics Assistant - Helped with the integration of this module into the WW2010 format and constructed home page graphic.

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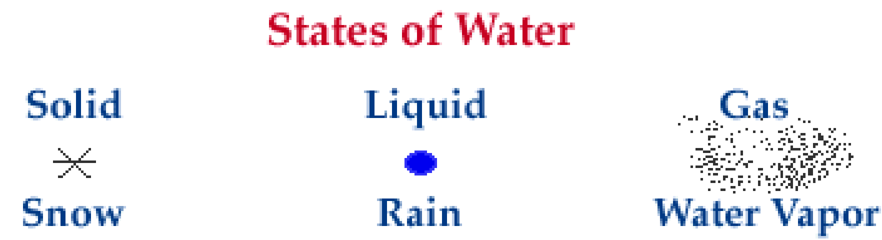
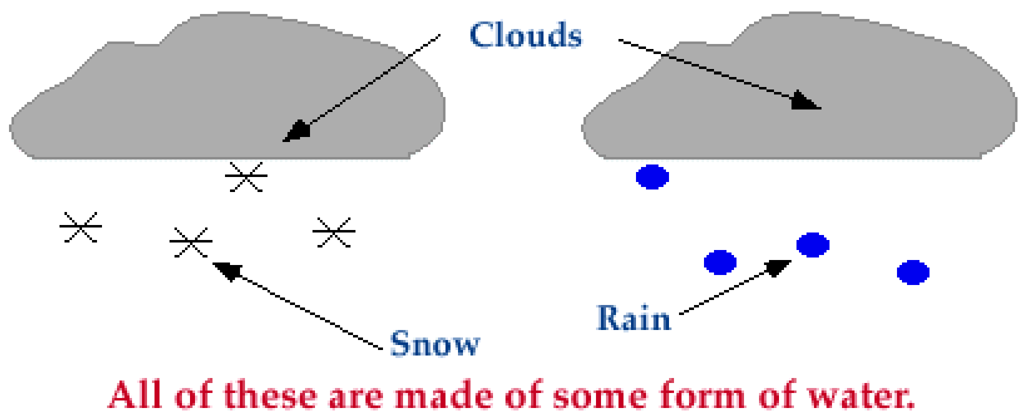
The States of Water

solid, liquid, gas

Water is known to exist in three different states; as a solid, liquid or gas.

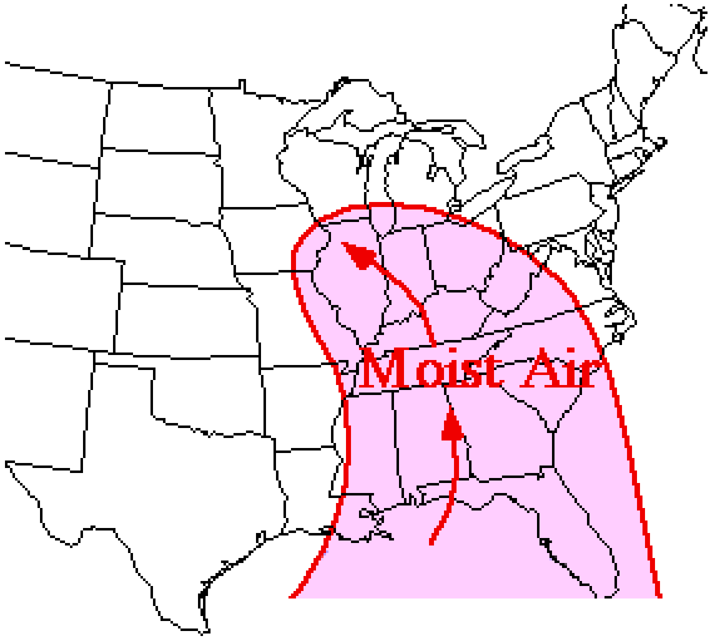


Clouds, snow, and rain are all made of up of some form of water. A cloud is comprised of tiny water droplets and/or ice crystals, a snowflake is an aggregate of many ice crystals, and rain is just liquid water.



Water existing as a gas is called water vapor. When referring to the amount of moisture in the air, we are actually referring to the amount of water vapor. If the air is described as "moist", that means the air contains large amounts of water vapor. Common sources of moisture for the United States are the warm moist air masses that flow northward from the Gulf of Mexico and western Atlantic Ocean as well as the moist Pacific air masses brought onshore by the westerlies.

As cyclones move eastward from the Rocky Mountains, southerly winds ahead of these storm systems transport the warm moist air northward. Moisture is a necessary ingredient for the production of clouds and precipitation.



Clounds, Precipitation

relative humidity

Cloud Types

common cloud classifications

Clouds are classified into a system that uses Latin words to describe the appearance of clouds as seen by an observer on the ground. The table below summarizes the four principal components of this classification system (Ahrens, 1994).

Latin Root	Translation	Example
cumulus	heap	fair weather cumulus
stratus	layer	altostratus
cirrus	curl of hair	cirrus
nimbus	rain	cumulonimbus

Further classification identifies clouds by height of cloud base. For example, cloud names containing the prefix "cirr-", as in cirrus clouds, are located at high levels while cloud names with the prefix "alto-", as in altostratus, are found at middle levels. This module introduces several cloud groups. The first three groups are identified based upon their height above the ground. The fourth group consists of vertically developed clouds, while the final group consists of a collection of miscellaneous cloud types.

[Image: thickening cirrus and cirrostratus at sunset (65K)]
Photograph by: Knupp

High-Level Clouds

High-level clouds form above 20,000 feet (6,000 meters) and since the temperatures are so cold at such high elevations, these clouds are primarily composed of ice crystals. High-level clouds are typically thin and white in appearance, but can appear in a magnificent array of colors when the sun is low on the horizon.

[Image: puffy altocumulus clouds (87K)]
Photograph by: Holle

Mid-Level Clouds

The bases of mid-level clouds typically appear between 6,500 to 20,000 feet (2,000 to 6,000 meters). Because of their lower altitudes, they are composed primarily of water droplets, however, they can also be composed of ice crystals when temperatures are cold enough.

- **Low-level Clouds**

Low clouds are of mostly composed of water droplets since their bases

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generally lie below 6,500 feet (2,000 meters). However, when temperatures are cold enough, these clouds may also contain ice particles and snow.

[Image: nimbostratus clouds (80K)]
Photograph by: Holle

Vertically Developed Clouds

Probably the most familiar of the classified clouds is the cumulus cloud. Generated most commonly through either thermal convection or frontal lifting, these clouds can grow to heights in excess of 39,000 feet (12,000 meters), releasing incredible amounts of energy through the condensation of water vapor within the cloud itself.

[Image: approaching cumulonimbus clouds at sunset (69K)]
Photograph by: Holle

Other Cloud Types

Finally, we will introduce a collection of miscellaneous cloud types which do not fit into the previous four groups.

Classifications

Last Update: 07/09/97

High-Level Clouds
Cloud types include: cirrus and cirrostratus.

Mid-Level Clouds
Cloud types include: altocumulus, altostratus.

Low-Level Clouds
Cloud types include: nimbostratus and stratocumulus.

Clouds with Vertical Development
Cloud types include: fair weather cumulus and cumulonimbus.

Other Cloud Types
Cloud types include: contrails, billow clouds, mammatus, orographic and pileus clouds.

Development

High-Level Clouds

[Image: home graphic (104K)]

Photograph by: Norene McGhiey

When cloud particles become too heavy to remain suspended in the air, they fall to the earth as precipitation. Precipitation occurs in a variety of forms; hail, rain, freezing rain, sleet or snow. This portion of the Clouds and Precipitation module focuses on precipitation and has been organized into the following sections.

Sections

Latest Update: 07/21/97

Rain and Hail
Atmospheric conditions that lead to the development of rain and hail.

Freezing Rain
A detailed look at freezing rain, associated dangers and the conditions that lead to its development.

Sleet
Atmospheric conditions that lead to the development of sleet.

Snow
Atmospheric conditions that lead to the development of snow.

Acknowledgments
Those who contributed to the Precipitation sections of the Clouds and Precipitation module.

The navigation menu (left) for this section is called "Precipitation" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

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Multiple Interfaces

different interfaces for different connectivity

[Image: graphics interface example (31K)]
Graphics Interface

In light of all this, we made it a high priority of WW2010 to not only be able to accommodate the high-bandwidth connections with lots of slick and fancy looking pages...

but not to forget that most people are accessing our resources through much slower connections. That is why each and every page is available in both a "graphics" or "text" based interface. In "text" mode, only very small inline images are downloaded.

[Image: text interface example (21K)]
Text Interface

A graphics-based and text-based example of the same page is shown here and the type of page that appears is controlled by the blue "User Interface" menu (left). The complete graphical representation of each page is obtained by clicking on "graphics", while in the "text" mode, are replaced by text links to these images.

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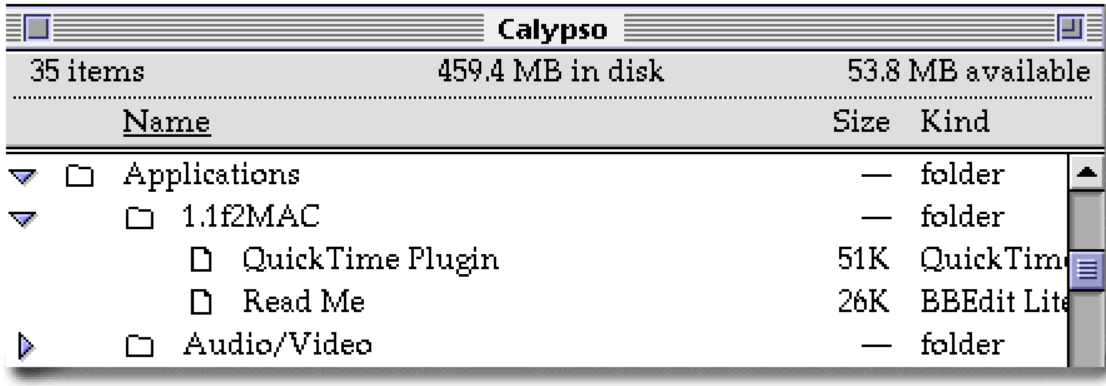
Navigating WW2010

menus and submenus

One of the unique features of WW2010 is the navigation bar along the left side of each page. Each menu resembles a folder on your computer desktop. A folder contains certain items which may either be individual files or additional subfolders, like in the image below.



For each menu, there is a corresponding menu title and the available items in that particular menu are listed below. Your current location within each menu is either highlighted in yellow or indicated by a small red arrow. (The indicator used depends upon the user interface and the web browser being used). In this case, the item "ww2010 user's guide" of the top menu called "Prerelease Info" is marked. This item opens a submenu titled "WW2010 User's Guide" and the item "core technologies" is marked. Then the item "Core Technologies" also contains a submenu of topics and so forth.

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About WW2010

information and insights

[Image: (23K)]

Thank you for your interest and welcome to WW2010 (Weather World 2010), our evolving earth sciences web server. WW2010 strives to integrate real time and archived data with instructional resources using new and innovative technologies.

. This purpose of this section is to introduce some of the new concepts and features that make up WW2010, the philosophies behind their development and how to use them. The WW2010 User's Guide is now available to provide a history of WW2010 plus valuable insights into key components of the web server, namely the content resources and core technologies.

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Vorticity Advection

leads to rising/falling pressures at the surface

Vorticity is the localized rotation of the air. Air that rotates counterclockwise, such as in cyclones and troughs, is said to have positive vorticity. Clockwise rotating air, such as in high pressure systems and ridges, has negative vorticity. The advection of vorticity at high levels will result in a response at the surface which will attempt to offset the effects of the advection. More specifically, vorticity advection is indicative of rising motion/falling pressures at the surface. For example, look at this 500 mb map for 12Z, October 29, 1995.

[Image: 500 mb heights and vorticity (112K)]

Now look at these two maps of surface pressure (solid lines) from 12Z October 29,1995 and 0Z October 30,1995.

[Image: surface pressure and temperature (54K)]

Notice how the surface low has deepened in the area of strong vorticity advection.

[Image: surface pressure and temperature (56K)]

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moistue advection

Clouds, Precipitation

Advection

advection
cold advection
warm advection
850 temp advection
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voriticity advection

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guidelines plus who to contact

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Hybrid Multimedia Educational CD-ROM

WW2010 (the weather world 2010 project)

[Image: CD-ROM logo (73K)]

The Weather World 2010 CD-ROM's are back!!!
If you would like to learn more about the CD-ROM, please read below.
If you would like to order, click here for a printable order form.

The Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) would like to announce the release of the 2nd edition of the Weather World 2010 (WW2010) Educational CD-ROM. This resource is being constructed to provide local access to the high-graphics version our entire collection of Internet-based educational resources developed through our participation in NSF's Collaborative Visualization Project (CoVis). Most of these resources are currently available in the Online Guides.

New to the 2nd Edition of the WW2010 CD-ROM:
As seen on the web

- A Completely new Hurricane instructional module filled with new graphics and movies.
- New Modeling section to the Severe Storms instructional module including movies, animations, research results, and online access to streaming video.
- New pages in the Forces and Winds instructional module.
- Updates to the Satellite and Light & Optics instructional modules.
- New pages describing WW2010 Current weather products.
- Plus many other updates and revisions to other instructional modules and background pages.

Features of the CD-ROM will include:

INSTRUCTIONAL MODULES - that use multimedia and the flexible nature of the web to enhance the impact of educational resources. These modules introduce and explain fundamental topics in Meteorology (Pressure, Severe Storms, El Niño, Forecasting etc.), Remote Sensing (Radars and Satellites) and how some of these aspects fit into the Hydrologic Cycle.
NOTE: The only resources found online and not on the CD-ROM are the Tropical Cyclone tracker and 3-D VRML Hurricane. They will still be accessible online from the CD-ROM.

ARCHIVED WEATHER DATA - and case studies of memorable weather events like Hurricane Andrew, Storm of the Century and the

April 19, 1996 Illinois Tornado Outbreak. Each case contains relevant weather images, storm histories, photographs and eye-witness accounts.

STUDENT PROJECTS & ACTIVITIES - (complete with answer keys) that provide teachers with a meaningful way of integrating the data and instructional resources into the classroom.

REAL-TIME WEATHER DATA - will also be accessible from selected pages of the CD-ROM to allow the user to apply what they've learned to current weather conditions. These pages will link to relevant weather products accessible through our WW2010 web server.

EFFICIENT NAVIGATION - that allows users to move between hundreds of pages with only a few clicks and return easily.

These resources will be accessible from the CD-ROM by using any standard web browser and the interface will be nearly identical to their online counterparts. Therefore the same CD-ROM can be used on a Macintosh or an PC.

For a printable order form, click here!

If you have any questions or comments, please contact us at **ww2010@atmos.uiuc.edu**

Acknowledgments

developers

Daniel Bramer

Multimedia Specialist/Webmaster - Developed and edited instructional modules and diagrams. Responsible for editing "About WW2010" section including obtaining copyright permissions. Assisted System Manager in creating the final version of the Weather World 2010 Current Weather Products and the format and appearance adjustments to the WW2010 Educational CD-ROM.

David Wojtowicz

System Manager/Resource Programmer - Developed the underlying software infrastructure for the server including the AutoTree menu/navigation system. Maintains the machines that it runs on. Created and developed the Weather World 2010 Current Weather Products and their generation system.

Steven E. Hall

UIUC Covis Project Coordinator - Developed or edited instructional resources, text diagrams and curriculum. Responsible for web server layout and appearance, graphic design and the integration of the instructional resources into the new framework.

Principal Investigators

Bob Wilhelmson - Acting Department Head and Professor of Atmospheric Sciences.

Mohan Ramamurthy - Associate Professor of Atmospheric Sciences

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Content Reviewers

DAS Students and Staff

Alex Brown - did the prototype design and HTML programming for constructing the text base navigation menus.

Bill Chapman - developed the early prototype of The Weather

Visualizer - a related product.

Paul Dekker - developed the original radar meteorology instructional module, graduated from this department in 1996.

Tom Grzelak - contributed to labeling of weather products and generation of multiple panel forecast images, received M.S. from this department in 1995.

Adam Houston - responsible for cover photograph for the CD-ROM.

Brian Jewett - took part in early developer meetings, developed several of the current weather products, developed simulations used in the Severe Storms instructional module.

Alan Liu - developed images for the El Niño instructional module, graduated from this department in 1997.

Geoff Manikin - constructed the Weather Forecasting instructional module, graduated from this department in 1995.

Norene McGhiey - transcribed text to the NOAA Severe Storms Spotters Guide, contributed to the April 19th Tornado Outbreak case study, and the Precipitation portion of the Clouds and Precipitation module.

Ed Mlodzik - constructed pages in the weather forecasting and midlatitude cyclones instructional modules, edited the Precipitation portion of the Clouds and Precipitation instructional module, took part in early developer meetings, helped prototype current weather products, graduated from this department in 1998.

Noah Nigg - developed the Virtual Reality Learning Tool for exploring hurricane Opal (VRML) for the Hurricane instructional Module

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Glen Romine - edited the Hurricanes instructional module.

Bruce Rose - constructed the Veteran's Day Snowstorm case study and took part in early developer meetings.

Crystal Shaw - helped with performance testing of WW2010, developed VRML scenes for the Severe Storms instructional module.

Yiqi Shao - constructed the Satellite Meteorology, El Niño, and the original Hurricanes instructional modules, plus the graphics design for a number of pages in the instructional modules.

Mythili Sridhar - constructed the original optics guide, the first online version of NOAA's Severe Storm Spotters Guide, graphically enhanced several modules, and prepared the CD-ROM for publication.

Ron Steve - constructed pages on the Forces and Winds instructional module, graduated from this department in 1996.

Vlad Tokarskiy - early Java developer (developed The Weather Animator) - a related product.

Jeff Van Dorn - constructed pages on the Air Masses and Fronts instructional module, responsible for cover photograph on 1st edition CD-ROM, graduated from this department in 1998.

Dave Werth - constructed pages on the Air Masses and Fronts instructional module, graduated from this department in 1997.

Kevin Wuebbles - helped transfer of old instructional modules to the new format.

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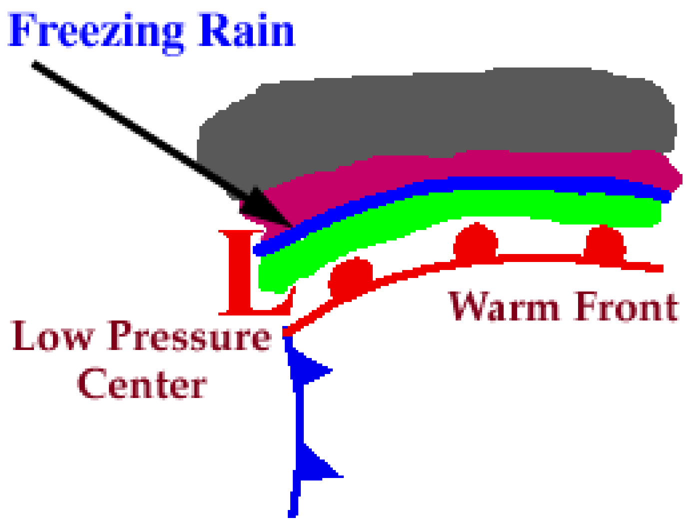
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

content reviewers

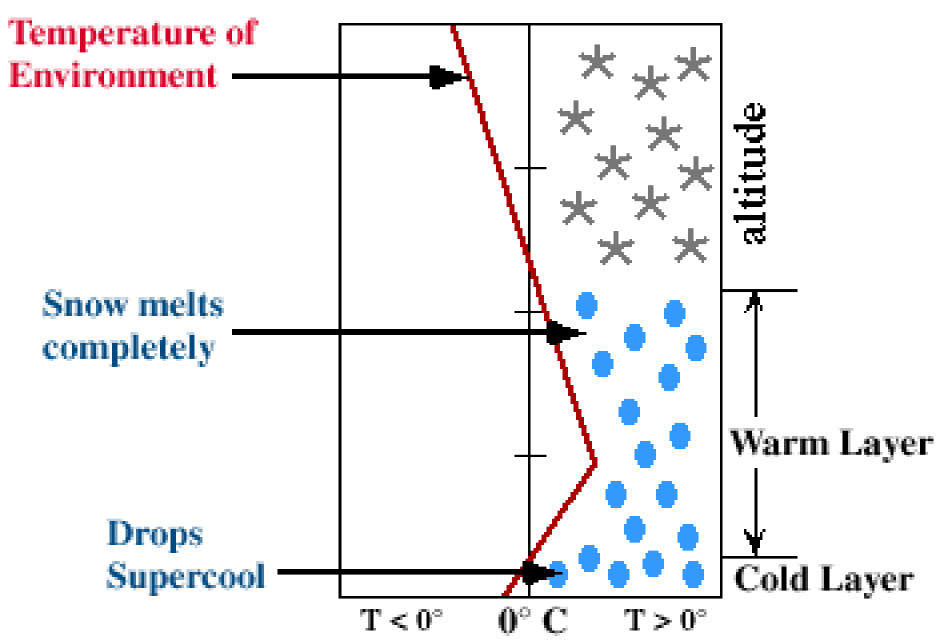
Freezing Rain

supercooled droplets freezing on impact

Ice storms can be the most devastating of winter weather phenomena and are often the cause of automobile accidents, power outages and personal injury. Ice storms result from the accumulation of freezing rain, which is rain that becomes supercooled and freezes upon impact with cold surfaces. Freezing rain is most commonly found in a narrow band on the cold side of a warm front, where surface temperatures are at or just below freezing.



The diagram below shows a typical temperature profile for freezing rain with the red line indicating the atmosphere's temperature at any given altitude. The vertical line in the center of the diagram is the freezing line. Temperatures to the left of this line are below freezing, while temperatures to the right are above freezing.



Freezing rain develops as falling snow encounters a layer of warm air deep enough for the snow to completely melt and become rain. As the rain continues to fall, it passes through a thin layer of cold air just above the surface and cools to a temperature below freezing. However, the drops themselves do not freeze, a phenomena called supercooling (or forming "supercooled drops"). When the supercooled drops strike the frozen ground (power lines, or tree branches), they instantly freeze, forming a thin film of ice, hence freezing rain.

Precipitation

Dangers

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Open-Ended Projects

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trusting the forecast

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[Image: projects image menu (56K)]

The fundamental philosophy behind the CoVis Project is to help kids learn science by doing projects, as opposed to the traditional learning out of textbooks. Part of this includes the integration of new and innovative technologies (like the Internet) into the classroom. To do this, we have developed two project units which provide teachers with a vehicle for using the Internet in a meaningful way to help kids learn science.

Projects

Last Update: 08/01/97

SuperStorm '93
This project investigates key weather processes and phenomena associated with a potent winter storm.

Trusting the Forecast
This project provides students with first hand experience in weather forecasting and all the issues a meteorologist must consider when issuing a forecast.

Two projects have been constructed, a Case Study of SuperStorm '93, a famous midlatitude cyclone that paralyzed the eastern third of the United States in March of 1993, and Trusting the Forecast, where students actually make forecasts on a regular basis to gain a full appreciation for all the preparation involved in making an accurate forecast. These units have been designed to take up to three weeks of class time in order to complete.

The navigation menu (left) for this module is called "Open-Ended Projects" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Projects, Activities

SuperStorm '93

[Image: main logo for student activities (47K)]
Graphic by: Steven E. Hall

The following classroom activities introduce a variety of fundamental topics in meteorology. All necessary data and instructional resources are accessible from each activity. In addition, each activity is accompanied by a corresponding teacher guide (or answer key). Up to 90 minutes of classroom time may be needed to complete each activity.

Activities

Last Update: 07/12/97

Pressure
Atmospheric pressure, high and low pressure centers, and the pressure gradient force.

Air Masses
Characteristics of air masses that commonly influence weather in the U.S. and how to identify them on weather maps.

Precipitation Along Fronts
The development of precipitation along warm fronts and cold fronts.

Midlatitude Cyclones
Anatomy of midlatitude cyclones and how to identify them on weather maps.

Coordinated Universal Time (UTC)
Converting back and forth between local time and UTC.

Surface Observation Symbols
Interpreting meteorological data from observation symbols displayed on weather maps.

Current Weather Symbols
Interpreting common weather symbols found on weather maps.

Forecasting Temperatures
Influences of cloud cover, wind, snow cover and advection on forecasting temperatures.

Forecasting Precipitation
Useful indicators for predicting the development of precipitation.

The navigation menu (left) for this module is called "Classroom Activities" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web

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server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Trusting the Forecast

pressure

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[Image: teacher guide logo (48K)]

Graphic by: Steven E. Hall

Each student activity is accompanied by a corresponding teacher guide, which consists of text and image answers to the questions asked in each activity. Text answers are presented in red colored text, while images have been modified so that the answers clearly stand out.

Guides

Last Update: 07/12/97

The navigation menu (left) for this module is called "Teacher Guides" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Classroom Activities

pressure

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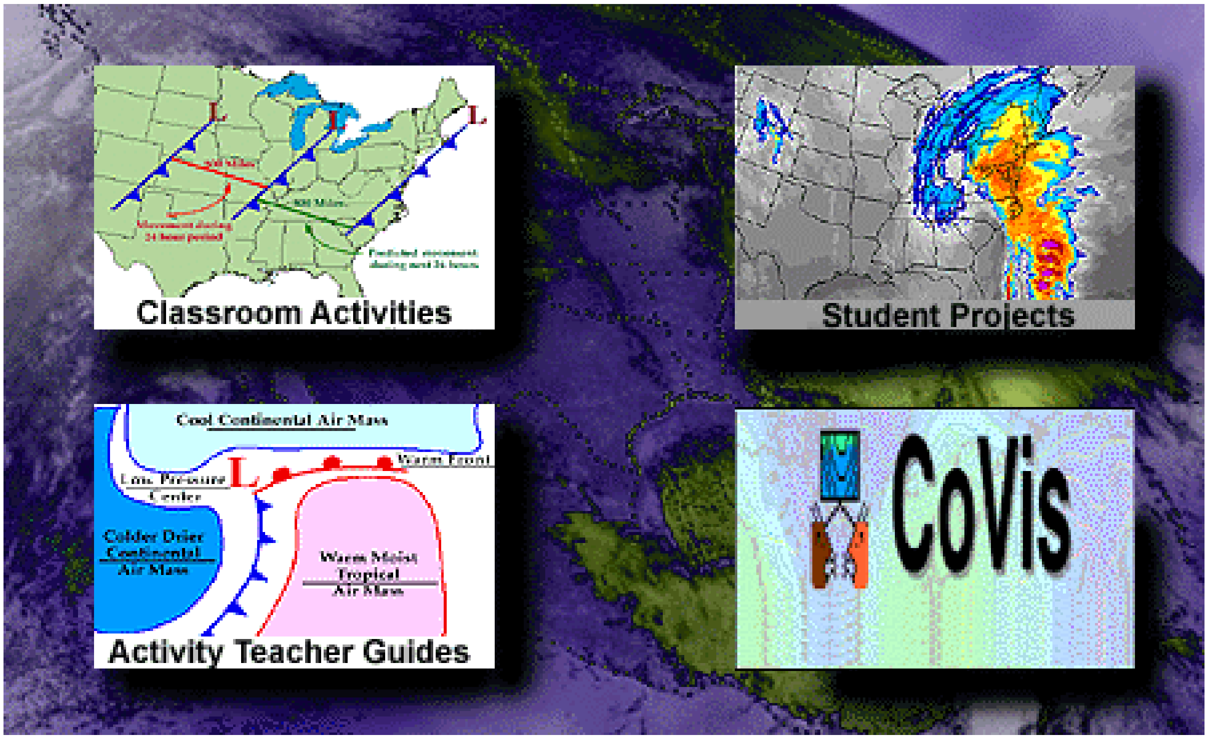
Classroom Activities
Student Projects
Cool Continental Air Mass
Warm Front
Low Pressure Center
Colder Drier Continental Air Mass
Warm Moist Tropical Air Mass
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Acknowledgments

organizations and institutions

We gratefully acknowledge the support of the National Science Foundation (NSF), through the Collaborative Visualization Project (CoVis) under NSF grant RED-9454729. We extend a special thank you to the entire CoVis team at Northwestern University.

Terms for using data resources. CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

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Multiple Interfaces

different interfaces for different connectivity

[Image: graphics interface example (31K)]
Graphics Interface

In light of all this, we made it a high priority of WW2010 to not only be able to accommodate the high-bandwidth connections with lots of slick and fancy looking pages...

but not to forget that most people are accessing our resources through much slower connections. That is why each and every page is available in both a "graphics" or "text" based interface. In "text" mode, only very small inline images are downloaded.

[Image: text interface example (21K)]
Text Interface

A graphics-based and text-based example of the same page is shown here and the type of page that appears is controlled by the blue "User Interface" menu (left). The complete graphical representation of each page is obtained by clicking on "graphics", while in the "text" mode, are replaced by text links to these images.

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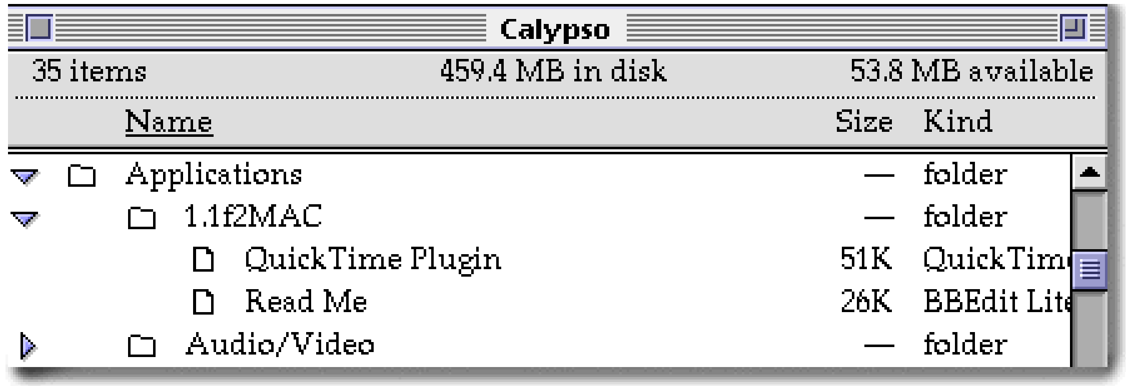
Navigating WW2010

menus and submenus

One of the unique features of WW2010 is the navigation bar along the left side of each page. Each menu resembles a folder on your computer desktop. A folder contains certain items which may either be individual files or additional subfolders, like in the image below.



For each menu, there is a corresponding menu title and the available items in that particular menu are listed below. Your current location within each menu is either highlighted in yellow or indicated by a small red arrow. (The indicator used depends upon the user interface and the web browser being used). In this case, the item "ww2010 user's guide" of the top menu called "Prerelease Info" is marked. This item opens a submenu titled "WW2010 User's Guide" and the item "core technologies" is marked. Then the item "Core Technologies" also contains a submenu of topics and so forth.

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About WW2010

information and insights

[Image: (23K)]

Thank you for your interest and welcome to WW2010 (Weather World 2010), our evolving earth sciences web server. WW2010 strives to integrate real time and archived data with instructional resources using new and innovative technologies.

This purpose of this section is to introduce some of the new concepts and features that make up WW2010, the philosophies behind their development and how to use them. The WW2010 User's Guide is now available to provide a history of WW2010 plus valuable insights into key components of the web server, namely the content resources and core technologies.

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Upper Air Obs

- overview
- temperature
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- wind barbs
- 300 winds & heights

User Interface

300 mb Winds and Heights

eta model forecast

[Image: (22K)]

Latest ETA Model 12 HR Forecast Panel

300 mb forecasted fields for geopotential height, wind speed and wind vectors. 300 mb charts depict conditions in the upper troposphere (roughly 9000 meters) where most of the weather producing phenomena occur, otherwise known as the jet stream level.

Geopotential height approximates the actual height of a pressure surface above mean sea-level and is represented by the solid white contours. The geopotential height field is given in meters with an interval of 120 meters between height lines. The 300 mb height field encircling the globe consists of a series of troughs and ridges, which are the upper air counterparts of surface cyclones and anticyclones. The distance from trough to trough (or ridge to ridge) is known as a longwave. Embedded within the longwaves are shortwaves, which are smaller disturbances often responsible for triggering surface cyclone development.

Wind vectors provide information about wind direction and wind speed and are drawn here as tiny red arrows. Wind vectors point towards the direction in which the wind is blowing and the longer the wind vector, the stronger the wind. The unit of magnitude for wind speed as depicted by the wind vectors is meters per second.

Wind speed is represented by the color filled regions and the intensity is indicated by the color code located in the lower left corner of the forecast panel. Wind speeds are given in knots with an interval of 20 knots between wind speed contours, also called isotachs. Wind speeds of less than 60 knots are represented by shades of blue while winds exceeding 120 knots are depicted in shades of red.

This information is useful in locating the jet stream, a narrow band of relatively strong winds encircling the earth in the upper troposphere. Wind speed maxima embedded within the jet stream, called jet streaks, are localized regions of high atmospheric energy that play a vital role in the development of surface low pressure centers. The closer together the height contours, the stronger the wind speed, which is why jet streaks are found where height contours are packed closely together.

---

wind barbs

Projects, Activities

graphics text

Terms for Using Text, Data and Images

guidelines plus who to contact

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For additional information contact: ww2010@atmos.uiuc.edu

CD-ROM available.
Credits and Acknowledgments for WW2010.
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the University of Illinois at Urbana-Champaign.

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Hybrid Multimedia Educational CD-ROM

WW2010 (the weather world 2010 project)

[Image: CD-ROM logo (73K)]

The Weather World 2010 CD-ROM's are back!!!
If you would like to learn more about the CD-ROM, please read below.
If you would like to order, click here for a printable order form.

The Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) would like to announce the release of the 2nd edition of the Weather World 2010 (WW2010) Educational CD-ROM. This resource is being constructed to provide local access to the high-graphics version our entire collection of Internet-based educational resources developed through our participation in NSF's Collaborative Visualization Project (CoVis). Most of these resources are currently available in the Online Guides.

New to the 2nd Edition of the WW2010 CD-ROM:
As seen on the web

- A Completely new Hurricane instructional module filled with new graphics and movies.
- New Modeling section to the Severe Storms instructional module including movies, animations, research results, and online access to streaming video.
- New pages in the Forces and Winds instructional module.
- Updates to the Satellite and Light & Optics instructional modules.
- New pages describing WW2010 Current weather products.
- Plus many other updates and revisions to other instructional modules and background pages.

Features of the CD-ROM will include:

INSTRUCTIONAL MODULES - that use multimedia and the flexible nature of the web to enhance the impact of educational resources. These modules introduce and explain fundamental topics in Meteorology (Pressure, Severe Storms, El Niño, Forecasting etc.), Remote Sensing (Radars and Satellites) and how some of these aspects fit into the Hydrologic Cycle.
NOTE: The only resources found online and not on the CD-ROM are the Tropical Cyclone tracker and 3-D VRML Hurricane. They will still be accessible online from the CD-ROM.

ARCHIVED WEATHER DATA - and case studies of memorable weather events like Hurricane Andrew, Storm of the Century and the

April 19, 1996 Illinois Tornado Outbreak. Each case contains relevant weather images, storm histories, photographs and eye-witness accounts.

STUDENT PROJECTS & ACTIVITIES - (complete with answer keys) that provide teachers with a meaningful way of integrating the data and instructional resources into the classroom.

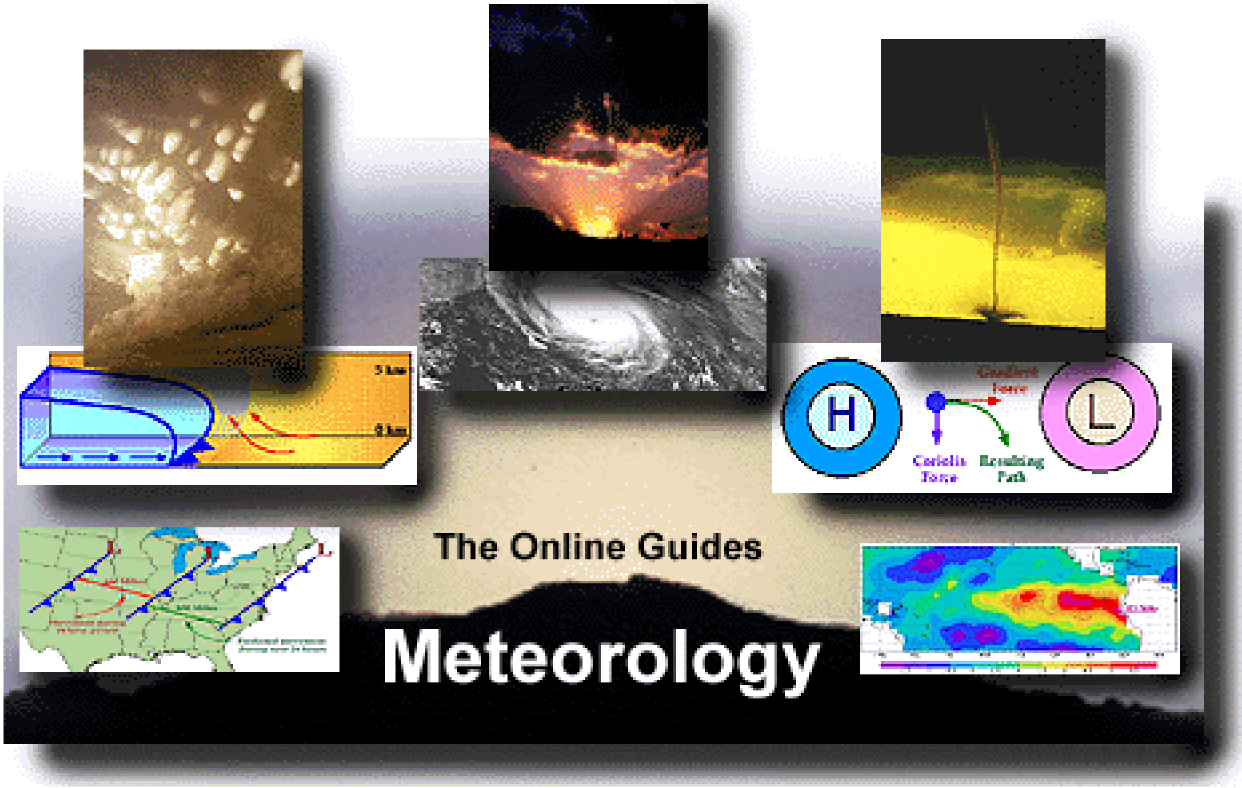
REAL-TIME WEATHER DATA - will also be accessible from selected pages of the CD-ROM to allow the user to apply what they've learned to current weather conditions. These pages will link to relevant weather products accessible through our WW2010 web server.

EFFICIENT NAVIGATION - that allows users to move between hundreds of pages with only a few clicks and return easily.

These resources will be accessible from the CD-ROM by using any standard web browser and the interface will be nearly identical to their online counterparts. Therefore the same CD-ROM can be used on a Macintosh or an PC.

For a printable order form, click here!

If you have any questions or comments, please contact us at **ww2010@atmos.uiuc.edu**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Acknowledgments

developers

Daniel Bramer

Multimedia Specialist/Webmaster - Developed and edited instructional modules and diagrams. Responsible for editing "About WW2010" section including obtaining copyright permissions. Assisted System Manager in creating the final version of the Weather World 2010 Current Weather Products and the format and appearance adjustments to the WW2010 Educational CD-ROM.

David Wojtowicz

System Manager/Resource Programmer - Developed the underlying software infrastructure for the server including the AutoTree menu/navigation system. Maintains the machines that it runs on. Created and developed the Weather World 2010 Current Weather Products and their generation system.

Steven E. Hall

UIUC Covis Project Coordinator - Developed or edited instructional resources, text diagrams and curriculum. Responsible for web server layout and appearance, graphic design and the integration of the instructional resources into the new framework.

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weather forecasting

Light, Optics

introduction
mechanisms
air, dust, haze
ice crystals

[Image: welcome banner (96K)]
Graphic by: Yiqi Shao

Rainbows, sunsets and halos; a spectacular display of colors and visuals in the sky called "atmospheric optics". As sunlight (or moonlight) enters the atmosphere, it is either absorbed, reflected, scattered, refracted or diffracted by atmospheric particles or air molecules. These processes, individually or in combination, are responsible for producing most optical effects. This module investigates these particle-light interactions and the assortment of optical effects they produce. The Light and Optics module has been organized into the following sections:

Sections

Last Update: 08/26/99

Mechanisms
Particle/Molecule-light interactions responsible for creating optical effects. These interactions include: reflection, scattering, refraction and diffraction.

Air, Dust, Haze
Optical effects resulting from the interaction of light with air, dust and haze particles. These effects include: crepuscular rays, blue skies, blue haze and sunsets.

Ice Crystals
Optical effects resulting from the interaction of light with ice crystals. These effects include: sundogs, sun pillars and halos.

Water Droplets
Optical effects resulting from the interaction of light with water droplets. These effects include: cloud iridescence, rainbows and a silver lining along the edge of clouds.

Acknowledgments
Those who contributed to the development of this module.

The type of optical effect that results greatly depends upon the type of particles the light encounters and on the wavelength of the light. For this reason, the optical effects discussed in this module have been grouped according to the following classifications of atmospheric particles: air, dust and haze, ice crystals, and water droplets.

The navigation menu (left) for this module is called "Light, Optics" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled by the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation water droplets

User Interface

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system, or WW2010 in general is accessible from About This Server.

Hydrologic Cycle

mechanisms

[Image: pressure home page logo (67K)]
Graphic by: Yiqi Shao

The weight of the air above an object exerts a force per unit area upon that object and this force is called pressure. Variations in pressure lead to the development of winds, which in turn influence our daily weather. The purpose of this module is to introduce pressure, how it changes with height and the importance of high and low pressure systems. In addition, this module introduces the pressure gradient and Coriolis forces and their role in generating wind. Local wind systems such as land breezes and sea breezes will also be introduced. The Forces and Winds module has been organized into the following sections:

Sections

Last Update: 09/02/99

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module.

The navigation menu (left) for this module is called "Forces, Winds" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

El Nino

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at the University of Illinois at Urbana-Champaign.

Pressure

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- severe storms
- weather forecasting

Air Masses, Fronts

- introduction
- air masses
- fronts
- advection

[Image: fronts welcome image (24K)]

Graphic by: Yiqi Shao

The purpose of this module is to introduce air masses, where they originate from and how they are modified. Clashing air masses in the middle latitudes spark interesting weather events and the boundaries separating these air masses are known as fronts. This module examines fronts, with detailed explanations about cold fronts and warm fronts. Finally, different types of advection are introduced; temperature, moisture and voriticity advection. The Air Masses and Fronts module has been organized into the following sections:

Sections

Last Update: 07/27/97

Air Masses

Air masses that commonly influence weather in the United States.

Fronts

Boundaries separating air masses. Includes warm fronts, cold fronts, occluded and stationary fronts and dry lines.

Advection

Introduces advection and describes the differences between warm and cold advection.

Acknowledgments

Those who contributed to the development of this module.

.

The navigation menu (left) for this module is called "Air Masses, Fronts" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Meteorology

Air Masses

User Interface

graphics text

[Image: Weather Forecasting Banner (48K)]

Graphic developed by: Dan Bramer

"Look for hazy skies with afternoon thunderstorms and a high of 95 degrees." Weather forecasts, such as this one, provide critical information about the weather to come. In severe weather situations, short-term forecasts and warnings can help save lives and protect property. It is vital that weather forecasts be as accurate as possible because so many people depend upon them. This module introduces forecast methods and the numerous factors one must consider when attempting to make an accurate forecast. The Weather Forecasting module has been organized into the following sections:

Sections

Last Update: 07/21/97

Forecasting Methods
Different forecasting methods for different weather scenarios.

Surface Features
Important surface features to consider when making a forecast.

Forecasting Temperatures
Factors to consider when forecasting day and nighttime temperatures.

Forecasting Precipitation
Factors to consider when forecasting precipitation.

Acknowledgments
Those who contributed to the development of this module.

The navigation menu (left) for this module is called "Weather Forecasting" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

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precipitation

User Interface

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[Image: severe weather home page image (95K)]
Graphic developed by: Dan Bramer

The Severe Storms Module is a combination of two elements. The first is the NOAA Severe Storms Spotters Guide. The second is a section recently added to discuss the efforts and results of modeling severe storms. The Severe Storms Spotters Guide contains supplemental instructional resources and a program designed to familiarize meteorologists and advanced severe storm spotters with the basic "building blocks" of convective storm structure. The focus of the training series is the development of a thunderstorm "spectrum" and a discussion of the physical characteristics and severe weather potential of the various storm types in the spectrum.

Sections

Last Update:05/15/99

Dangers of Thunderstorms
Includes: lightning, floods, hail, winds and tornadoes.

Types of Thunderstorms
Single cells, multicell clusters, multicell lines (squall lines) and supercells.

Components of Thunderstorms
Updrafts and downdrafts, outflow phenomena, wall clouds and the effects of wind shear on thunderstorm development.

Tornadoes
Tornadoes, cyclic storms and low-level flow fields associated with tornadic thunderstorms.

Modeling
Supercells, squall lines, and other phenomena recreated inside computers for the benefit of forecasting and understanding.

Acknowledgments
Those who contributed to the development of this module.

The critical role of atmospheric dynamics and thermodynamics in determination of storm type is stressed. We will take a close look at the storms themselves; from the small, summer storms capable of producing dangerous "microbursts" to the large "supercell" storms which spawn destructive tornadoes.

The navigation menu (left) for this module is called "Severe Storms" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in

tornadoes
modeling

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both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Upper Air Features

Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at the University of Illinois at Urbana-Champaign.

Dangers of T-storms

[Image: home page image (61K)]
Graphic by: Yiqi Shao

Periodically, the flourishing fish populations commonly found off the west coast of Peru South America are replaced by the sight of dead fish littering the water and beaches. Unusual weather conditions occur around the globe as jet streams, storm tracks and monsoons are shifted. Such disarray is caused by a warm current of water that appears every three to seven years in the eastern Pacific Ocean called El Niño. This module introduces El Niño, conditions are responsible for its occurrence, plus the impact it has on the rest of the world. The El Niño instructional module has been organized into the following sections:

Sections

Last Update: 04/28/98

Definition
Introduces El Niño, when El Niño events have been recorded and how it compares to La Niña.

'97-'98 Event
Provides a brief insight into the most recent El Niño event.

Upwelling
Introduces upwelling, the thermocline and how they impact local sea life populations.

Non-El Niño Years
Typical oceanic and atmospheric conditions that exist in the tropical Pacific when no El Niño is present..

El Niño Events
Conditions that lead to an El Niño event and how El Niño influences upwelling processes, tropical rainfall and local fish populations.

Sea Surface Temperatures
El Niño visualized through sea surface temperature anomaly plots.

Impacts on Weather
The influence of El Niño on weather conditions worldwide.

Economic Impacts
Reduction in local fish populations, which in turn affect local industry and market prices worldwide.

Detection and Prediction
Methods and resources used by NOAA for detecting and

User Interface

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predicting the presence of El Niño.

Acknowledgments
Those who contributed to the development of this module.

The navigation menu (left) for this module is called "El Nino" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

Precipitation

definition

[Image: Hydrologic Graphic (76K)]
Graphic by: Dan Bramer

Water is the source of all life on earth. The distribution of water, however, is quite varied; many locations have plenty of it while others have very little. Water exists on earth as a solid (ice), liquid or gas (water vapor). Oceans, rivers, clouds, and rain, all of which contain water, are in a frequent state of change (surface water evaporates, cloud water precipitates, rainfall infiltrates the ground, etc.). However, the total amount of the earth's water does not change. The circulation and conservation of earth's water is called the "hydrologic cycle". The Hydrologic Cycle module has been organized into the following sections:

Sections

Last Update: 07/21/97

The Earth's Water Budget
The distribution of water among the oceans, land and atmosphere.

Evaporation
The transformation of water from a liquid into a gas, a process which humidifies the atmosphere.

Condensation
The transformation of water from a gas into a liquid, and the processes that lead to condensation.

Transport
The movement of water through the atmosphere.

Precipitation
The transfer of water from the atmosphere to land. Rain, snow, hail, sleet, and freezing rain are discussed.

Groundwater
Water located below ground and how it returns to the surface.

Transpiration
Transfer of water to the atmosphere by plants and vegetation.

Runoff
Rivers, lakes, and streams transport water from land to the oceans. Too much rainfall can cause excess runoff, or flooding.

Summary and Example

A brief encapsulation of the hydrologic cycle, plus an example of the hydrologic cycle at work.

Acknowledgments
Those who contributed to the development of this module.

User Interface

graphics text

The navigation menu (left) for this module is called "Hydrologic Cycle" and the menu items are arranged in a recommended sequence, beginning with this introduction. In addition, this entire web server is accessible in both "graphics" and "text"-based modes, a feature controlled from the blue "User Interface" menu (located beneath the black navigation menus). More information about the user interface options, the navigation system, or WW2010 in general is accessible from About This Server.

WW2010
University of Illinois

Helper Menu

- exit helper
- helper page
- more detail

Acknowledgments

organizations and institutions

We gratefully acknowledge the support of the National Science Foundation (NSF), through the Collaborative Visualization Project (CoVis) under NSF grant RED-9454729. We extend a special thank you to the entire CoVis team at Northwestern University.

WW2010
University of Illinois

Helper Menu

exit helper
helper page
more detail

Acknowledgments

organizations and institutions

We would like to acknowledge the support of the Department of Atmospheric Sciences at the University of Illinois Urbana-Champaign.

Terms for using data resources. CD-ROM available.
Credits and Acknowledgments for WW2010.
Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

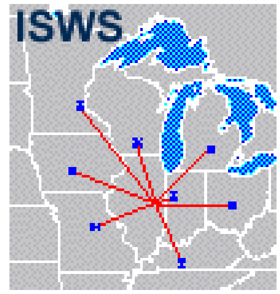
WW2010
University of Illinois

Helper Menu

- exit helper
- helper page
- more detail

Acknowledgments

organizations and institutions



We would like to acknowledge the support of the Illinois State Water Survey (ISWS).

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Terms for using data resources. CD-ROM available.
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Department of Atmospheric Sciences (DAS) at
the University of Illinois at Urbana-Champaign.

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Helper Menu

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- more detail

Multiple Interfaces

different interfaces for different connectivity

[Image: graphics interface example (31K)]
Graphics Interface

In light of all this, we made it a high priority of WW2010 to not only be able to accommodate the high-bandwidth connections with lots of slick and fancy looking pages...

but not to forget that most people are accessing our resources through much slower connections. That is why each and every page is available in both a "graphics" or "text" based interface. In "text" mode, only very small inline images are downloaded.

[Image: text interface example (21K)]
Text Interface

A graphics-based and text-based example of the same page is shown here and the type of page that appears is controlled by the blue "User Interface" menu (left). The complete graphical representation of each page is obtained by clicking on "graphics", while in the "text" mode, are replaced by text links to these images.

WW2010
University of Illinois

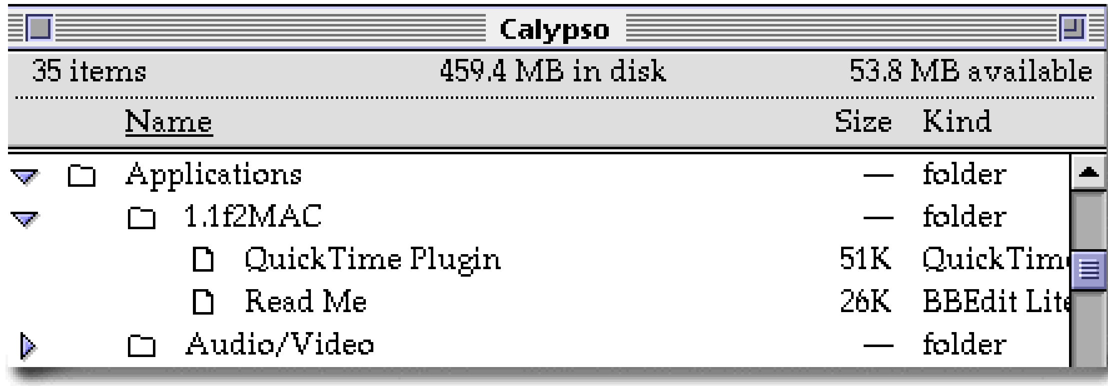
Helper Menu

- exit helper
- helper page
- more detail

Navigating WW2010

menus and submenus

One of the unique features of WW2010 is the navigation bar along the left side of each page. Each menu resembles a folder on your computer desktop. A folder contains certain items which may either be individual files or additional subfolders, like in the image below.



For each menu, there is a corresponding menu title and the available items in that particular menu are listed below. Your current location within each menu is either highlighted in yellow or indicated by a small red arrow. (The indicator used depends upon the user interface and the web browser being used). In this case, the item "ww2010 user's guide" of the top menu called "Prerelease Info" is marked. This item opens a submenu titled "WW2010 User's Guide" and the item "core technologies" is marked. Then the item "Core Technologies" also contains a submenu of topics and so forth.

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Helper Menu

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About WW2010

information and insights

[Image: (23K)]

Thank you for your interest and welcome to WW2010 (Weather World 2010), our evolving earth sciences web server. WW2010 strives to integrate real time and archived data with instructional resources using new and innovative technologies.

. This purpose of this section is to introduce some of the new concepts and features that make up WW2010, the philosophies behind their development and how to use them. The WW2010 User's Guide is now available to provide a history of WW2010 plus valuable insights into key components of the web server, namely the content resources and core technologies.

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the University of Illinois at Urbana-Champaign.

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Helper Menu

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Terms for Using Text, Data and Images

guidelines plus who to contact

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- **Non-Commercial Use:** Non-commercial use must be accompanied by appropriate credit visible with respect to the used item. "Image/Text/Data from the University of Illinois WW2010 Project." Web utilizations should, if possible, provide a link to our server nearby.
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For additional information contact: ww2010@atmos.uiuc.edu

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Helper Menu

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Hybrid Multimedia Educational CD-ROM

WW2010 (the weather world 2010 project)

[Image: CD-ROM logo (73K)]

The Weather World 2010 CD-ROM's are back!!!
If you would like to learn more about the CD-ROM, please read below. If you would like to order, click here for a printable order form.

The Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC) would like to announce the release of the 2nd edition of the Weather World 2010 (WW2010) Educational CD-ROM. This resource is being constructed to provide local access to the high-graphics version our entire collection of Internet-based educational resources developed through our participation in NSF's Collaborative Visualization Project (CoVis). Most of these resources are currently available in the Online Guides.

New to the 2nd Edition of the WW2010 CD-ROM:
As seen on the web

- A Completely new Hurricane instructional module filled with new graphics and movies.
- New Modeling section to the Severe Storms instructional module including movies, animations, research results, and online access to streaming video.
- New pages in the Forces and Winds instructional module.
- Updates to the Satellite and Light & Optics instructional modules.
- New pages describing WW2010 Current weather products.
- Plus many other updates and revisions to other instructional modules and background pages.

Features of the CD-ROM will include:

INSTRUCTIONAL MODULES - that use multimedia and the flexible nature of the web to enhance the impact of educational resources. These modules introduce and explain fundamental topics in Meteorology (Pressure, Severe Storms, El Niño, Forecasting etc.), Remote Sensing (Radars and Satellites) and how some of these aspects fit into the Hydrologic Cycle.
NOTE: The only resources found online and not on the CD-ROM are the Tropical Cyclone tracker and 3-D VRML Hurricane. They will still be accessible online from the CD-ROM.

ARCHIVED WEATHER DATA - and case studies of memorable weather events like Hurricane Andrew, Storm of the Century and the

April 19, 1996 Illinois Tornado Outbreak. Each case contains relevant weather images, storm histories, photographs and eye-witness accounts.

STUDENT PROJECTS & ACTIVITIES - (complete with answer keys) that provide teachers with a meaningful way of integrating the data and instructional resources into the classroom.

REAL-TIME WEATHER DATA - will also be accessible from selected pages of the CD-ROM to allow the user to apply what they've learned to current weather conditions. These pages will link to relevant weather products accessible through our WW2010 web server.

EFFICIENT NAVIGATION - that allows users to move between hundreds of pages with only a few clicks and return easily.

These resources will be accessible from the CD-ROM by using any standard web browser and the interface will be nearly identical to their online counterparts. Therefore the same CD-ROM can be used on a Macintosh or an PC.

For a printable order form, click here!

If you have any questions or comments, please contact us at **ww2010@atmos.uiuc.edu**

U.S. Environmental Protection Agency

Clean Air Markets

Recent Additions | Contact Us | Print Version Search:

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EPA Home > Clean Air Markets > Recent Additions

Doing Business With Us

Programs and Regulations

Progress and Results

Allowance Trading

Reports and Articles

Data and Maps

Acid Deposition Monitoring

Environmental Issues

Recent Additions

August 6, 2004

- We are pleased to announce that EPA has published a final rule revising Subpart GG of 40 CFR Part 60, which simplifies emissions monitoring, testing and reporting for combustion turbines that are simultaneously regulated under Part 60 and 40 CFR Part 75. This rule, published on July 8, 2004 (See 69 FR pp. 41346-41364) , represents the completion of the Turbine Initiative effort, which the Agency undertook in response to concerns from the regulated community. The Turbine Initiative helps resolving testing and reporting inconsistencies and redundancies between Part 60 and Part 75, improves the cost-effectiveness of monitoring, and simplifies the process of determining compliance. The Office of Air Quality Planning and Standards (OAQPS) and the Clean Air Markets Division (CAMD) worked together on this Initiative to ensure a high level of harmony between both regulations. For questions or comments, contact Jaime Pagan of OAQPS at 919-541-5340 and either Ruben Deza of CAMD at 202-343-9364 or Bob Vollaro of CAMD at 202-343-9116.

June 21, 2004

- MDC Version 4.2.48 .The current version of MDC is Version 4.2.48, revised as of June 15, 2004. This version of MDC supersedes MDC version 4.2.46 which was previously posted in March, 2004. EPA is releasing this version of MDC to provide a less stringent QA Status Evaluation (in MDC Hourly) for linearity checks of both ranges of dual range analyzer components (e.g., NOXA, SO2A, SO2H, SO2L, etc.) to make sure false errors are not generated. New logic has been added to handle the alternate specification for low-flow RATAs. MDC v4.2.48 also includes minor fixes to problems that were reported in the previous version. The changes and fixes are detailed in the Release Notes document.

- New section of MDC CAMD Export Files has been added to provide access to the current monitoring plan and quality assurance test data stored in the CAMD's MDC database.

June 15, 2004

- Presentations from the June 10, 2004, NOx SIP Call Monitoring and Reporting Workshop are now available.

- The Clean Air Markets Division is currently writing documents to PDF using Adobe Acrobat **Version 6.0**. If you are having problems opening PFD documents, you may need to upgrade to a current version. Free Upgrade to Adobe Acrobat 6.0 EXIT disclaimer

April 29, 2004

- EPA 2003 Blind Audit of Protocol Calibration Gases for CEMS. This link is to three self explanatory tables (1) Cal Gas Audit Pass Fail Summary; (2) Cal Gas Audit Detailed Results; and (3) Cal Gas Audit Failure Rate by Reference Standard. It is important to read the footnotes on the tables.

- Presentations for the Milwaukee, WI, workshop added to the website

April 16, 2004

- **NEW!!** The Clean Air Markets Division is happy to announce the addition of the States and Regions area of our website! This area is intended to provide to our web users a place where all information specific to states and regions can be found. This page can also be accessed through the Doing Business with Us area of the CAMD website.

- NOx SIP Call Implementation Workshop, June 10, 2004 in Washington, D.C.

April 15, 2004

- Cap and Trade: Improving Human Health and the Environment

April 9, 2004

- EMA 8th Annual Spring Meeting, May 3-5 2004, New Orleans, Louisiana

March 25, 2004

- The OTC NOx Budget Program (1999-2002): Summary of EPA Discussion Papers on Emission Trading Issues

March 23, 2004

- 2004 Allowance Auction Results

March 17, 2004

- News Concerning the 2004 EPA SO2 Allowance Auction

March 16, 2004

- MDC Version 4.2.46 . The current version of MDC is Version 4.2.46, revised as of March 15, 2004. This version of MDC supersedes MDC version 4.1.42 which was previously posted in December, 2003. This new version is being released to provide **significant changes** to the QA Status Evaluation portion of MDC Hourly. Unlike previous versions, it does not rely on RTs 697, 698 or 699 to determine test deadline extensions or test exemptions due to non-QA operating quarters, linearity exemptions due to low span values, or grace period extensions. This version also **checks the linearity status of both ranges of dual range analyzer components** (e.g., NOXA, SO2A etc) to make sure required tests were performed. MDC v4.2.46 also includes minor fixes to problems that were reported in the previous version. The changes and fixes are detailed in the Release Notes document.

March 16, 2004

- Summary of 2003 EPA Audit of Protocol Gases

March 9, 2004

- Allowances Available for the 2004 EPA Auction

- When sending deliveries to CAMD via express services, please mark all deliveries with the name and phone number of the person to whom the package should be delivered.

February 18, 2004

- 2004 Compliance for the NOx Budget Program

- The Clean Air Markets Division is currently writing documents to PDF using Adobe Acrobat Version 5.0. If you are having problems opening PFD documents, you may need to upgrade to version 5.0. Free Upgrade to Adobe Acrobat 5.0 EXIT disclaimer

February 2, 2004

- A revised spreadsheet for **Rectangular Duct Wall Effects** is now posted at the same web address as the original. The revised version corrects three small technical, not substantive errors in the originally posted spreadsheet. The first problem was that the ln() function was used instead of the exp() function in the roughness calculation. The second problem was that a "<" instead of a ">" was used in one of the conditional statements required by 8.4.2(b). And, the third problem did not allow the 8.4.1 option to be calculated for smaller ducts. Also, a brief CTM-041 calculations instruction document is now available.

December 18, 2003

- Rectangular Duct Wall Effects . EPA is allowing the use of an optional rectangular duct wall effects conditional test method (CTM-041) for source personnel that perform flow monitor relative accuracy testing in a rectangular stack or duct.

December 15, 2003

- MDC Version 4.1.42 . The current version of MDC is Version 4.1.42, revised as of December 15, 2003. This version of MDC supersedes MDC version 4.1(.36) which was previously posted in August, 2003. This new version is being released specifically to support the use of an optional wall effects conditional test method (CTM_041) for facilities that perform flow RATAs in rectangular stacks or ducts. It also includes minor fixes to problems that were reported in the previous version. These fixes are detailed in the Release Notes document, If you do not need the changes to support rectangular ducts and you have not encountered any of the problems described in the release notes, you do not need to upgrade to this version of MDC.

U.S. Environmental Protection Agency

Clean Air Markets

Contact Us

Call the Acid Rain Hotline:
202-343-9620

Regular or certified mail address:
US EPA
Clean Air Markets Division
1200 Pennsylvania Avenue, NW
Mail Code 6204J
Washington, DC 20460

Overnight mail address:
Package delivery / Street address:
US EPA
Clean Air Markets Division (6204J)
1310 L Street, NW
Washington, DC 20005
Tel: (202) 343-9150

Use the form below to send us a comment or question

Web Site Comments and Questions

EPA's Clean Air Markets Division runs this Web site. If you need information about acid rain, its effects, or what we're doing to solve this problem, try the following links:

1. Acid rain overview
2. Environmental effects of acid rain
3. Acid rain progress report (an Adobe Acrobat document)
4. Maps of rainfall acidity (pH) EXIT disclaimer
5. Acid Rain Program

If you would like a reply to your comment, please enter an email address and phone number below and check that they are correct. We will only use contact information to reply; we will not collect or disseminate it.

Note that we need a complete email address of the form "name@somewhere.ending" in order to reply. For example, if you use AOL and your screen name is "Visitor," you need to enter "visitor@aol.com" instead of "visitor" by itself.

If you have problems using this form, please send your comments by email to walke.cynthia@epa.gov.

We collect questions and answers for publication to help future visitors find information quickly. We will only publish comments, not any identifying information about you. However, if you would prefer that your comment not be published, please check ☐ here.

Your name

Your organization

Your email address

Required, if you seek a reply.

Phone number

Can help us contact you if your email isn't working

Comments

Include mailing address if requesting paper copies of publications

Last updated on Wednesday, November 6th, 2002
URL: http://www.epa.gov/airmarkt/index.html

U.S. Environmental Protection Agency

Clean Air Markets - Environmental Issues

Recent Additions | Contact Us | Search: GO

EPA Home > Clean Air Markets > Environmental Issues > Acid Rain > Effects of Acid Rain

Home | Business | Programs | Progress | Trading | Reports | Data and Maps | Monitoring | Issues

Effects of Acid Rain

Acid rain causes acidification of lakes and streams and contributes to damage of trees at high elevations (for example, red spruce trees above 2,000 feet) and many sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints, including irreplaceable buildings, statues,and sculptures that are part of our nation's cultural heritage. Prior to falling to the earth, SO2 and NOx gases and their particulate matter derivatives, sulfates and nitrates, contribute to visibility degradation and harm public health.

The links below provide more detailed information on each of these effects.

- Surface waters (e.g., lakes and streams) and animals living in them
- Forests
- Automotive Coatings (e.g., car paint)
- Materials
- Visibility
- Human Health

CAM Update | Forms | Workshops | Glossary
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This page was generated on Sunday, August 29, 2004

View the graphical version of this page at: http://www.epa.gov/airmarkets/acidrain/effects/index.html

U.S. Environmental Protection Agency

Clean Air Markets

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Doing Business With Us

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Environmental Issues

Students and Teachers

Acid Rain Students Site

Acid Rain Kids Site

Welcome to the Clean Air Markets Web site.

Clean air markets programs include various market-based regulatory programs designed to improve air quality. The most well-known of these programs is EPA's Acid Rain Program, which has the overall goal of achieving environmental and public health benefits through reductions in emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x)—compounds produced by fossil fuel combustion that adversely affect air quality, the environment, and public health. In addition to information on the Acid Rain Program, you will also find information at this site on other programs that employ cap-and-trade mechanisms.

Clean Air Market Programs

What is "Cap and Trade"?

- The Acid Rain Program
- The OTC NOx Budget Trading Program
- SIP Call/NOx Budget Trading Program

Proposed Programs

- Clear Skies Legislation

- Interstate Air Quality Rule
- Utility Mercury Reductions Rule

Environmental Issues

- Acid Rain | En Español
- Smog/Ozone Transport
- Regional Haze /Particulate Matter
- Climate Change

News Bulletins

- Cap and Trade: Improving Human Health and the Environment
- 2004 Allowance Auction Results
- EPA Acid Rain Program 2002 Progress Report
- New Acid Rain Student's Site launched
- Peer Review Panel Meeting on Natural Gas Supply Assumptions, October 23-24, 2003
- Informational Session on Coal Supply Assumptions, October 29, 2003
- 2003 NOx SIP Call Emissions Data
- Clean Air Markets Update #4
- 2002 Ozone Transport Commission NOx Budget Program Compliance Report
- Clearing the Air: The Facts about Capping and Trading Emissions
- Recent Additions

Environmental Issues

EPA's Clean Air Market Programs address several environmental issues using emissions caps and allowance trading. This section of the site provides information about each, especially scientific details.

- Acid Rain
  Acid deposition, or acid rain as it is commonly known, occurs when emissions of sulfur dioxide (SO2) and oxides of nitrogen (NOx) react in the atmosphere with water, oxygen, and oxidants to form various acidic compounds. These compounds then fall to the earth in either dry form (such as gas and particles) or wet form (such as rain, snow, and fog). Prevailing winds transport the compounds hundreds of miles, across state lines and national borders.
- Smog / Ozone Transport
  Smog is a brownish haze that usually appears over cities in summertime. Smog can make breathing difficult for some people, and it also can impair visibility. The main component of smog is ground-level ozone, a gas that is created when NOx reacts with other chemicals in the air, especially in the presence of strong sunlight. NOx can travel long distances before reacting to form ozone, creating regional problems instead of just affecting the local area where it is emitted.
- Regional Haze
  Regional haze is the visibility impairment that occurs when particles and gases in the atmosphere, including sulfates and nitrates, scatter and absorb light. The pollutants that are associated with acid rain are the same ones that reduce visibility. Visibility tends to vary by season and geography because it is also affected by the angle of the sunlight and the level of humidity. High relative humidity heightens pollution's effects on visibility because particles, such as sulfates, accumulate water and grow to a size at which they scatter more light, creating haze.
- Climate Change
  According to scientists, the Earth's surface has risen in temperature by about 1 degree Fahrenheit in the past century. There is increasing

evidence that certain human activities are contributing to this change in temperature through activities that increase the levels of greenhouse gases, primarily carbon dioxide, methane, and nitrous oxide, in the atmosphere. Greenhouse gases trap heat that would normally escape back into the atmosphere, thus increasing the Earth's natural greenhouse effect and increasing temperature over time. To learn more about greenhouse gasses, view the Greenhouse Gas Inventory

Smog / Regional Transport of Ozone

Smog is the brownish haze that pollutes our air, particularly over cities in the summertime. Smog can make it difficult for some people to breathe and it greatly reduces how far we can see through the air.

The primary component of smog is ozone, a gas that is created when nitrogen oxides (NOx) react with other chemicals in the atmosphere, especially in strong sunlight. NOx is produced whenever we burn something, such as coal in a power plant or gasoline in a car's engine.

Like sulfur dioxide, NOx can travel large distances before reacting to form ozone. For that reason, it creates regional pollution problems, rather than simply affecting the local area where it is emitted. EPA has taken several steps to reduce NOx emissions, including the Acid Rain Program and NOx allowance trading programs.

For more information about ozone and its effects, including maps of ozone concentrations, see EPA's AIRNOW Web site.

Acid Rain
Smog/Ozone Transport
Regional Haze
Climate Change
Students and Teachers

Acid Rain Students Site

Regional Haze/Particulate Matter

Regional haze is the "dirty-looking" air that prevents us from seeing clearly or very far through the air. It especially affects our enjoyment of national parks, such as the Grand Canyon and the Great Smoky Mountains. Sulfate particles, formed by the reaction of sulfur dioxide (SO2) from power plants and other sources in the atmosphere, account for 50 to 70 percent of the visibility reduction in the eastern part of the United States. Both sulfate and nitrate particles (resulting from nitrogen oxides emissions) affect visibility in the western U.S.

The Acid Rain Program is expected to improve the visual range in the eastern U.S. by 30 percent by cutting SO2 emissions from electric utilities by 50% from 1980 levels. Based on a study of the value national park visitors place on visibility, the visual range improvements expected at national parks in the eastern United States due to the Acid Rain Program's SO2 reductions will be worth over a billion dollars annually by the year 2010. In the western part of the United States, nitrates and carbon also play roles, but sulfates have been implicated as an important source of visibility impairment in many of the Colorado River Plateau national parks, including the Grand Canyon, Canyonlands, and Bryce Canyon.

Visit EPA's visibility Web site for information about EPA's other efforts to reduce regional haze.

U.S. Environmental Protection Agency

Clean Air Markets - Environmental Issues

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EPA Home > Clean Air Markets > Environmental Issues > Climate Change

Home | Business | Programs | Progress | Trading | Reports | Data and Maps | Monitoring | Issues

Acid Rain

Smog/Ozone Transport

Regional Haze

Climate Change

Students and Teachers

Acid Rain Students Site

Climate Change

The Earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases - primarily carbon dioxide, methane, and nitrous oxide. The heat-trapping property of these gases is undisputed. Although uncertainty exists about exactly how earth's climate responds to these gases, global temperatures are rising. Visit EPA's global warming website for more information about climate change.

EPA prepares a national inventory of United States greenhouse gas emissions each year for submission under the United Nations Framework Convention on Climate Change. The Clean Air Markets Division coordinates the development of this inventory and leads the inter-agency greenhouse gas inventory team. Visit EPA's national greenhouse gas inventory website.

CAM Update | Forms | Workshops | Glossary
Site Map | About Us | Questions and Answers | Other Resources

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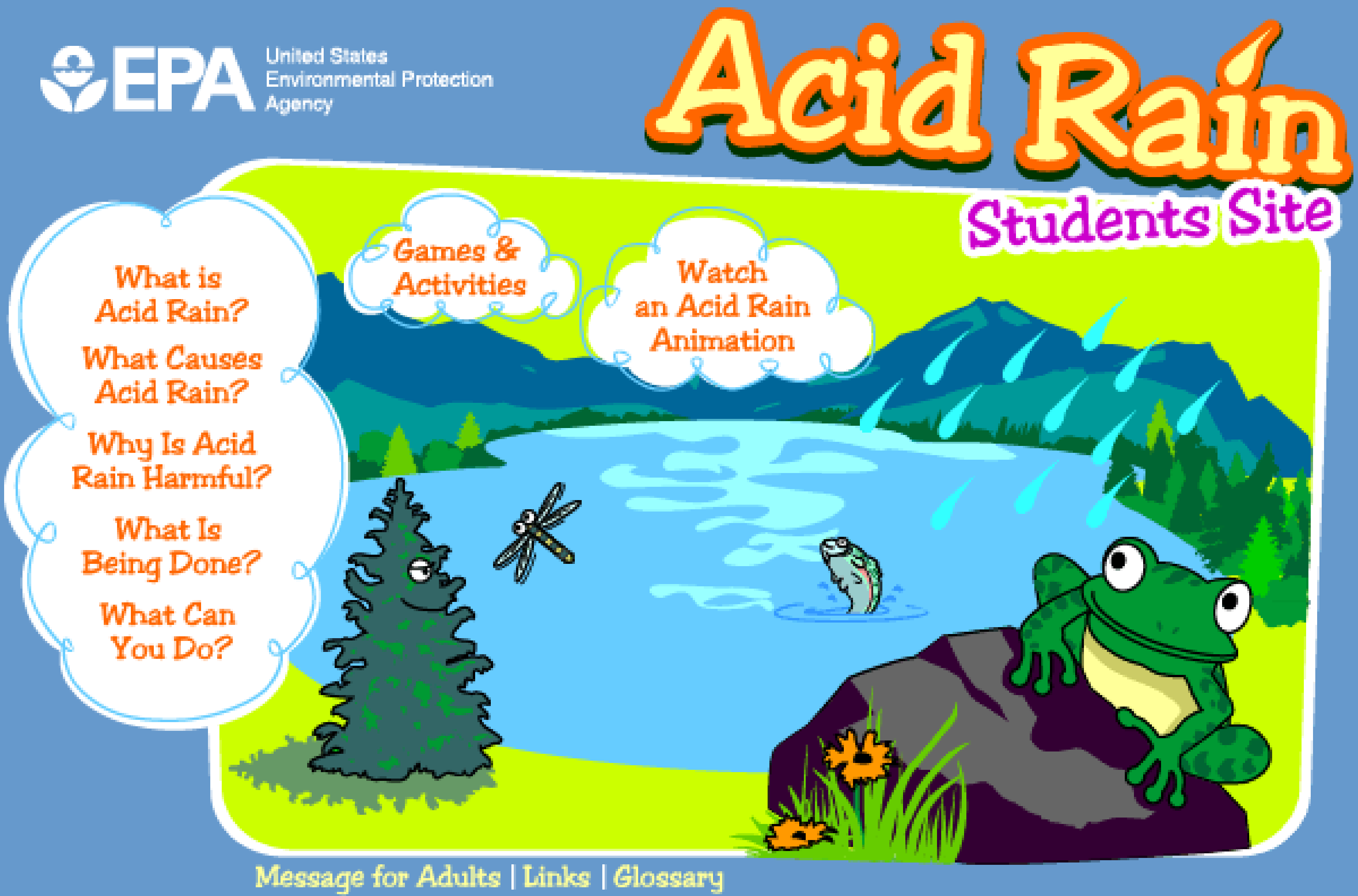


Some features of this site require the latest version of Macromedia Flash Player. Download a free copy of [Macromedia Flash Player](#)

EXIT disclaimer

[EPA](#) | [Air & Radiation](#) | [Air Markets](#) | [EPA Student Center](#) | [Contact Us](#)

Acid Deposition Data

Acid deposition takes two forms:

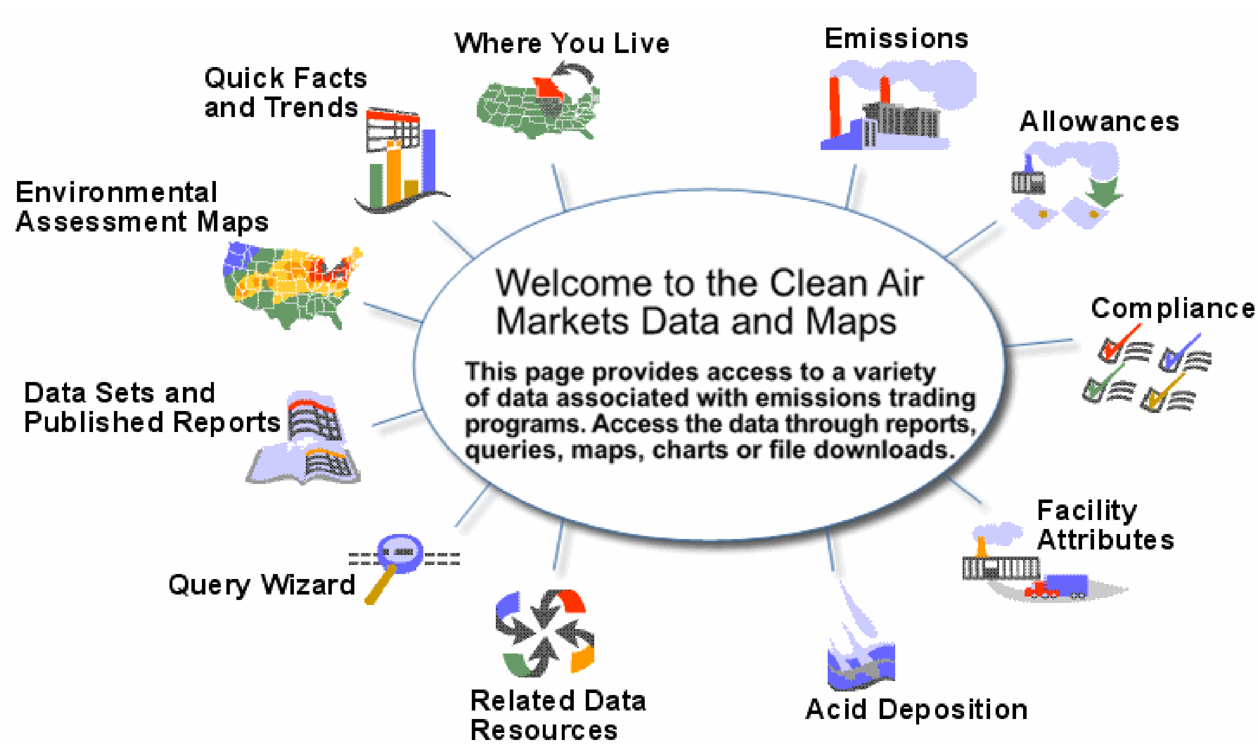
- Wet Deposition
  - monitored by the National Atmospheric Deposition Program EXIT EPA
  - occurs when sulfur dioxide and nitrogen oxides react in the atmosphere with water vapor
  - returns to earth as acidic water
  - commonly referred to as "acid rain"
  - also includes acid snow and acid fog
  - data are used to produce maps, called isopleth maps, that show pH and other chemical characteristics of rainfall
  - ranges from 40 - 80 % of total deposition

- Dry Deposition
  - monitored by the Clean Air Status & Trends Network (CASTNET)
  - occurs when sulfur dioxide and nitrogen oxides react, but not with water
  - settles out of the atmosphere as particles or gases
  - not as well understood as wet deposition
  - ranges from 20 - 60 % of total deposition

Total deposition is what causes environmental effects, so it is important to understand both wet and dry deposition. NADP and CASTNET provide vital information for both scientific understanding and policy evaluation and decision making. The networks' home pages, linked above, provide much more detail about their structure, quality control, and results.

U.S. Environmental Protection Agency

Clean Air Markets - Data and Maps



This page design was last updated on Wednesday, May 12, 2004.

Acid Rain Program

Allowance Trading and Cap and Trade

Acid Deposition and Air Quality

Benefits and Costs Assessments

NOx Programs

Fact Sheets and Reports

Library

This site contains Clean Air Markets publications and reference materials by program topics. These include CAMD fact sheets and reports as well as additional reports and peer reviewed articles which provide good information on CAMD programs.

- **Acid Rain Program**
- **Allowance Trading**
- **Benefits and Costs Assessments**
- **NOx Programs**
- **Acid Deposition and Air Quality**

Complete listing of all Clean Air Markets Fact Sheets and Reports

Allowance Trading

EPA's Clean Air Market Programs use cap and trade programs to address environmental issues. This section of the site focuses on trading concepts, program design considerations, and tracking of allowances in our programs:

- Buying allowances
  Learn the options for anyone to buy and sell allowances, including the Acid Rain Program allowance auctions

- Sulfur Dioxide (SO2) and Nitrogen Oxides (NOx) allowance & market data
  - Allowance Tracking Systems
    EPA's database of SO2 and NOx allowance accounts and transfers
  - SO2 market analysis
  - NOx market analysis
- Allowance allocations under the Acid Rain Program
  Information about how allowances are initially distributed to emission sources

- Programs using emissions trading
  - Acid Rain Program
  - NOx State Implementation Plan (SIP) Call Home Page
  - Ozone Transport Commission (OTC) NOx Budget Program (1999-2001)

- Compliance: ensuring allowances exceed emissions
  - Compliance reports
    Include information about allowance usage and "banked" allowances - amounts saved for future use
  - Annual reconciliation

How EPA compares emissions and allowances under the Acid Rain Program

Articles & papers about SO2 allowance trading

- Cap and Trade: Improving Human Health and the Environment
- Clearing The Air: The Truth About Capping and Trading Emissions (PDF 498KB)
- Trading basics - a guide to how cap and trade works
- Tools of the Trade: A Guide to Designing and Operating a Cap and Trade Program for Pollution Control.

When corresponding with the Clean Air Markets Division, use the below addresses. We recommend using overnight delivery services to ensure timely receipt of documents. Please include a contact name on all deliveries.

- **Street Address (Overnight mail and package delivery):**
  US EPA
  Clean Air Markets Division
  1310 L Street., NW
  Mail Code 6204J
  Washington, DC 20005
  Telephone: (202) 343-9150

- **Regular or certified mail:**
  US EPA
  Clean Air Markets Division
  1200 Pennsylvania Avenue, NW
  Mail Code 6204J
  Washington, DC 20460

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- Compliance
- Data and Maps

Progress and Results

- Data and Interactive Tools
  - Emissions Data
  - Compliance Reports
  - Maps and Geographic Information System (GIS) Datasets
  - Sulfur dioxide (SO2) Allowance Market Analysis
  - Nitrogen Oxides (NOx) Allowance Market Analysis
  - Tools produced and maintained by EPA's Climate Protection Partnetship Division:
    - eGRID2002 Version 2.0
    - Power Profiler
- Acid Deposition Monitoring
  - Clean Air Status & Trends Network (CASTNET)
    Dry deposition monitoring
  - National Atmospheric Deposition Program (NADP)
    EXIT disclaimer
    Wet deposition monitoring; includes maps showing rainfall pH across the US (called isopleth maps)
- OTC NOx Budget Program 1999-2002 Progress Report
- 2002 Acid Rain Program Progress Report
- 2001 Acid Rain Program Progress Report
- 2000 Acid Rain Program Progress Report

- 1999 Acid Rain Program Progress Report
- National Acid Precipitation Assessment Report (NAPAP) "Biennial Report to Congress: an Integrated Assessment." May 1998 EXIT disclaimer
- Reports, Articles, and Papers
- Clean Air Markets Update

Programs and Regulations

EPA's Clean Air Market Programs include several regulatory programs designed to address a variety of environmental issues. The regulations are available, along with accompanying guidance. In addition, information is provided about the US-Canada Air Quality Agreement and other international programs that use cap and trade concepts.

- Acid Rain Program
  Reductions in sulfur dioxide (SO2) & nitrogen oxides, trading of SO2 allowances
- NOx Trading Programs
  - Summary table - quick description of the different programs
  - Ozone Transport Commission (OTC) NOx Budget Program
  - NOx State Implementation Plan (SIP) Call
- Monitoring Guidance (for all programs)
- Reporting Emissions (for all programs)
- Forms for All Programs
- Compliance Reports (for all programs)
- US - Greenhouse Gas Inventory
- US - Canada Air Quality Agreement
- The Latest Update of EPA Modeling Applications (v.2.1)Using The Integrated Planning Model (IPM)
  IPM is a key analytical tool in evaluating the economic and environmental impacts of environmental programs on the electric power

sector.

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Effects of Acid Rain: Lakes & Streams

The ecological effects of acid rain are most clearly seen in the aquatic, or water, environments, such as streams, lakes, and marshes. Acid rain flows to streams, lakes, and marshes after falling on forests, fields, buildings, and roads. Acid rain also falls directly on aquatic habitats. Most lakes and streams have a pH between 6 and 8, although some lakes are naturally acidic even without the effects of acid rain. Acid rain primarily affects sensitive bodies of water, which are located in watersheds whose soils have a limited ability to neutralize acidic compounds (called "buffering capacity"). Lakes and streams become acidic (pH value goes down) when the water itself and its surrounding soil cannot buffer the acid rain enough to neutralize it. In areas where buffering capacity is low, acid rain also releases aluminum from soils into lakes and streams; aluminum is highly toxic to many species of aquatic organisms.

Where Does Acid Rain Affect Lakes and Streams?

Many lakes and streams examined in a National Surface Water Survey (NSWS) suffer from chronic acidity, a condition in which water has a constant low pH level. The survey investigated the effects of acidic deposition in over 1,000 lakes larger than 10 acres and in thousands of miles of streams believed to be sensitive to acidification. Of the lakes and streams surveyed, acid rain caused acidity in 75 percent of the acidic lakes and about 50 percent of the acidic streams. Several regions in the U.S. were identified as containing many of the surface waters sensitive to acidification. They include the Adirondacks and Catskill Mountains in New York state, the mid-Appalachian highlands along the east coast, the upper Midwest, and mountainous areas of the Western United States. In areas like the Northeastern United States, where soil buffering capacity is poor, some lakes now have a pH value of less than 5. One of the most acidic lakes reported is Little Echo Pond in Franklin, New York. Little Echo Pond has a pH of 4.2.

Acidification is also a problem in lakes that were not surveyed in federal research projects. For example, although lakes smaller than 10 acres were not included in the NSWS, there are from one to four times as many of these small lakes as there are larger lakes. In the Adirondacks, the percentage of acidic lakes is significantly higher when it includes smaller lakes.

Streams flowing over soil with low buffering capacity are as susceptible to damage from acid rain as lakes. Approximately 580 of the streams in the Mid-Atlantic Coastal Plain are acidic primarily due to acidic deposition. In the New Jersey Pine Barrens, for example, over 90 percent of the streams are acidic, which is the highest rate of acidic streams in the nation. Over 1,350 of the streams in the Mid-Atlantic Highlands (mid-Appalachia) are acidic, primarily due to acidic deposition.

The acidification problem in both the United States and Canada grows in magnitude if "episodic acidification" is taken into account. Episodic acidification refers to brief periods during which pH levels decrease due to runoff from melting snow or heavy downpours. Lakes and streams in many areas throughout the United States are sensitive to episodic acidification. In the Mid-Appalachians, the Mid-Atlantic Coastal Plain, and the Adirondack Mountains, many additional lakes and streams become temporarily acidic during storms and spring snowmelt. For example, approximately 70 percent of sensitive lakes in the Adirondacks are at risk of episodic acidification. This amount is over three times the amount of chronically acidic lakes. In the mid-Appalachians, approximately 30 percent of sensitive streams are likely to become acidic during an episode. This level is seven times the number of chronically acidic streams in that area. Episodic acidification can cause "fish kills."

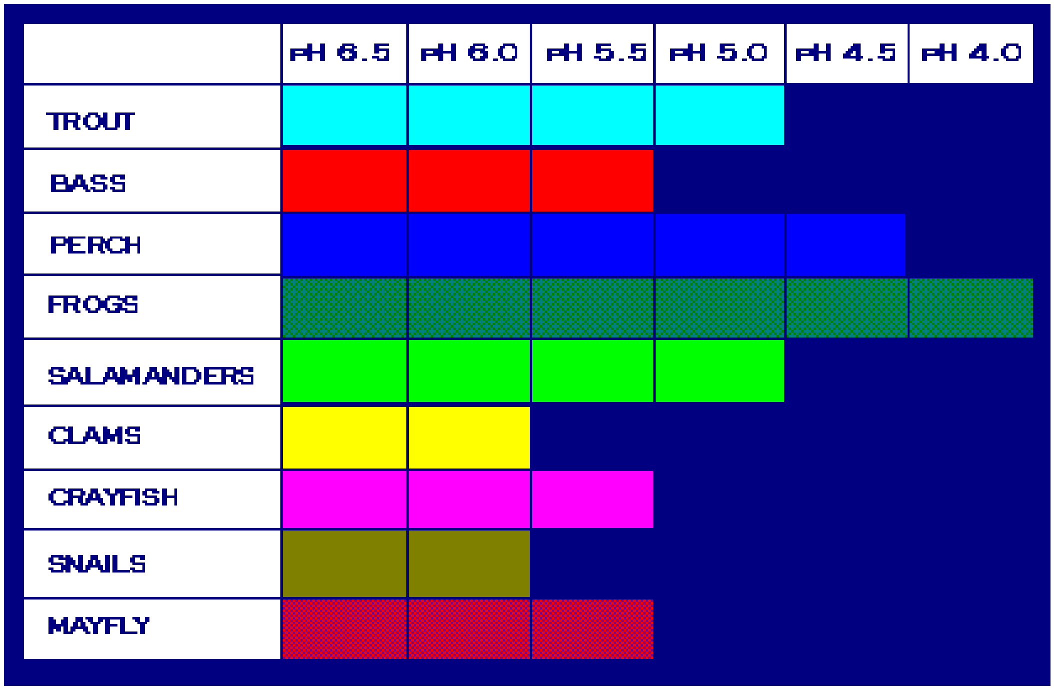
Emissions from U.S. sources also contribute to acidic deposition in eastern Canada, where the soil is very similar to the soil of the Adirondack Mountains, and the lakes are consequently extremely vulnerable to chronic acidification problems. The Canadian government has estimated that 14,000 lakes in eastern Canada are acidic.

How Does Acid Rain Affect Fish and Other Aquatic Organisms?

Acid rain causes a cascade of effects that harm or kill individual fish, reduce fish population numbers, completely eliminate fish species from a waterbody, and decrease biodiversity. As acid rain flows through soils in a watershed, aluminum is released from soils into the lakes and streams located in that watershed. So, as pH in a lake or stream decreases, aluminum levels increase.

Both low pH and increased aluminum levels are directly toxic to fish. In addition, low pH and increased aluminum levels cause chronic stress that may not kill individual fish, but leads to lower body weight and smaller size and makes fish less able to compete for food and habitat.

Some types of plants and animals are able to tolerate acidic waters. Others, however, are acid-sensitive and will be lost as the pH declines. Generally, the young of most species are more sensitive to environmental conditions than adults. At pH 5, most fish eggs cannot hatch. At lower pH levels, some adult fish die. Some acid lakes have no fish. The chart below shows that not all fish, shellfish, or the insects that they eat can tolerate the same amount of acid; for example, frogs can tolerate water that is more acidic (has lower pH) than trout.



How Does Acid Rain Affect Ecosystems?

Together, biological organisms and the environment in which they live are called an ecosystem. The plants and animals living within an ecosystem are highly interdependent. For example, frogs may tolerate relatively high levels of acidity, but if they eat insects like the mayfly, they may be affected because part of their food supply may disappear. Because of the connections between the many fish, plants, and other organisms living in an aquatic ecosystem, changes in pH or aluminum levels affect biodiversity as well. Thus, as lakes and streams become more acidic, the numbers and types of fish and other aquatic plants and animals that live in these waters decrease.

What is the Role of Nitrogen in Acid Rain and other Environmental Problems?

The impact of nitrogen on surface waters is also critical. Nitrogen plays a significant role in episodic acidification and new research recognizes the importance of nitrogen in long-term chronic acidification as well. Furthermore, the adverse impact of atmospheric nitrogen deposition on estuaries and near-coastal water bodies is significant. Scientists estimate that from 10-45 percent of the nitrogen produced by various human activities that reaches estuaries and coastal ecosystems is transported and deposited via the atmosphere. For example, about 30 percent of the nitrogen in the Chesapeake Bay comes from atmospheric deposition. Nitrogen is an important factor in causing eutrophication (oxygen depletion) of water bodies. The symptoms of eutrophication include blooms of algae (both toxic and non-toxic), declines in the health of fish and shellfish, loss of seagrass beds and coral reefs, and ecological changes in food webs. According to the National Oceanic and Atmospheric Administration, these conditions are common in many of our nation's coastal ecosystems. These ecological changes impact human populations by changing the availability of seafood and creating a risk of consuming contaminated fish or shellfish, reducing our ability to use and enjoy our coastal ecosystems, and causing economic impact on people who rely on healthy coastal ecosystems, such as fishermen and those who cater to tourists.

How is the Acid Rain Program Addressing These Issues?

Acid rain control will produce significant benefits in terms of lowered surface water acidity. If acidic deposition levels were to remain constant over the next 50 years (the time frame used for projection models), the acidification rate of lakes in the Adirondack Mountains that are larger than 10 acres would rise by 50 percent or more. Scientists predict, however, that the decrease in SO2 emissions required by the Acid Rain Program will significantly reduce acidification due to atmospheric sulfur. Without the reductions in SO2 emissions, the proportions of acidic aquatic ecosystems would remain high or dramatically worsen.

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Acid Rain Students Site

Effects of Acid Rain: Forests

Over the years, scientists, foresters, and others have watched some forests grow more slowly without knowing why. The trees in these forests do not grow as quickly at a healthy pace. Leaves and needles turn brown and fall off when they should be green and healthy. In extreme cases, individual trees or entire areas of the forest simply die off without an obvious reason.

Researchers now know that acid rain causes slower growth, injury, or death of forests. Acid rain has been implicated in forest and soil degradation in many areas of the eastern United States, particularly high elevation forests of the Appalachian Mountains from Maine to Georgia that include areas such as the Shenandoah and Great Smoky Mountain National Parks. Of course, acid rain is not the only cause of such conditions. Other things that add stress, such as air pollutants, insects, disease, drought, or very cold weather also harm trees and plants. In most cases, in fact, the impacts of acid rain on trees occur due to the combined effects of acid rain and these other environmental stressors. After many years of collecting information on the chemistry and biology of forests, researchers are beginning to understand how acid rain works on the forest soil, trees, and other plants.

- Acid Rain on the Forest Floor
- How Acid Rain Harms Trees
- How Acid Rain Affects Other Plants

Acid Rain on the Forest Floor

A spring shower in the forest washes leaves and falls through the trees to the forest floor below. Some trickles over the ground and runs into a stream, river, or lake, and some of the water soaks into the soil. That soil may neutralize some or all of the acidity of the acid rainwater. This ability is called buffering capacity, and without it, soils become more acidic. Differences in soil buffering capacity are an important reason why some areas that receive acid rain show a lot of damage, while other areas that receive about the same amount of acid rain do not appear to be harmed at all. The ability of forest soils to resist, or buffer, acidity depends on the thickness and composition of the soil, as well as the type of bedrock beneath the forest floor. Midwestern states like Nebraska and Indiana have soils that are well buffered. Places in the mountainous northeast, like New York's Adirondack and Catskill Mountains, have thin soils with low buffering capacity.

How Acid Rain Harms Trees

Acid rain does not usually kill trees directly. Instead, it is more likely to weaken trees by damaging their leaves, limiting the nutrients available to them, or exposing them to toxic substances slowly released from the soil. Quite often, injury or death of trees is a result of these effects of acid rain in combination with one or more additional threats.

Scientists know that acidic water dissolves the nutrients and helpful minerals in the soil and then washes them away before trees and other plants can use them to grow. At the same time, acid rain causes the release of substances that are toxic to trees and plants, such as aluminum, into the soil. Scientists believe that this combination of loss of soil nutrients and increase of toxic aluminum may be one way that acid rain harms trees. Such substances also wash away in the runoff and are carried into streams, rivers, and lakes. More of these substances are released from the soil when the rainfall is more acidic.

However, trees can be damaged by acid rain even if the soil is well buffered. Forests in high mountain regions often are exposed to greater amounts of acid than other forests because they tend to be surrounded by acidic clouds and fog that are more acidic than rainfall. Scientists believe that when leaves are frequently bathed in this acid fog, essential nutrients in their leaves and needles are stripped away. This loss of nutrients in their foliage makes trees more susceptible to damage by other environmental factors, particularly cold winter weather.

How Acid Rain Affects Other Plants

Acid rain can harm other plants in the same way it harms trees. Although damaged by other air pollutants such as ground level ozone, food crops are not usually seriously affected because farmers frequently add fertilizers to the soil to replace nutrients that have washed away. They may also add crushed limestone to the soil. Limestone is an alkaline material and increases the ability of the soil to act as a buffer against acidity.

The Effects of Acid Rain on Automotive Coatings

Over the past two decades, there have been numerous reports of damage to automotive paints and other coatings. The reported damage typically occurs on horizontal surfaces and appears as irregularly shaped, permanently etched areas. The damage can best be detected under fluorescent lamps, can be most easily observed on dark colored vehicles, and appears to occur after evaporation of a moisture droplet. In addition, some evidence suggests damage occurs most frequently on freshly painted vehicles. Usually the damage is permanent; once it has occurred, the only solution is to repaint.

The general consensus within the auto industry is that the damage is caused by some form of environmental fallout. "Environmental fallout," a term widely used in the auto and coatings industries, refers to damage caused by air pollution (e.g., acid rain), decaying insects, bird droppings, pollen, and tree sap. The results of laboratory experiments and at least one field study have demonstrated that acid rain can scar automotive coatings. Furthermore, chemical analyses of the damaged areas of some exposed test panels showed elevated levels of sulfate, implicating acid rain.

The popular term "acid rain" refers to both wet and dry deposition of acidic pollutants that may damage material surfaces, including auto finishes. These pollutants, which are released when coal and other fossil fuels are burned, react with water vapor and oxidants in the atmosphere and are chemically transformed into sulfuric and nitric acids. The acidic compounds then may fall to earth as rain, snow, fog, or may join dry particles and fall as dry deposition. Automotive coatings may be damaged by all forms of acid rain, including dry deposition, especially when dry acidic deposition is mixed with dew or rain. However, it has been difficult to quantify the specific contribution of acid rain to paint finish damage relative to damage caused by other forms of environmental fallout, by the improper application of paint or by deficient paint formulations. According to coating experts, trained specialists can differentiate between the various forms of damage, but the best way of determining the cause of chemically induced damage is to conduct a detailed, chemical analysis of the damaged area.

Because evaporation of acidic moisture appears to be a key element in the damage, any steps taken to eliminate its occurrence on freshly painted vehicles may alleviate the problem. The steps include frequent washing followed by hand drying, covering the vehicle during precipitation events, and use of one of the protective coatings currently on the market that claim to protect the original finish. (However, data on the performance of these coatings are not yet sufficient.)

The auto and coatings industries are fully aware of the potential damage and are actively pursuing the development of coatings that are more resistant to environmental fallout, including acid rain. The problem is not a universal one-- it does not affect all coatings or all vehicles even in geographic areas known to be subject to acid rain-- which suggests that technology exists to protect against this damage. Until that technology is implemented to protect all vehicles or until acid deposition is adequately reduced, frequent washing and drying and covering the vehicle appear to be the best methods for consumers who wish to minimize acid rain damage.

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- Regional Haze
- Climate Change
- Students and Teachers

Acid Rain Students Site

Effects of Acid Rain: Materials

Acid rain and the dry deposition of acidic particles contribute to the corrosion of metals (such as bronze) and the deterioration of paint and stone (such as marble and limestone). These effects seriously reduce the value to society of buildings, bridges, cultural objects (such as statues, monuments, and tombstones), and cars.

Dry deposition of acidic compounds can also dirty buildings and other structures, leading to increased maintenance costs. To reduce damage to automotive paint caused by acid rain and acidic dry deposition, some manufacturers use acid-resistant paints, at an average cost of $5 for each new vehicle (or a total of $61 million per year for all new cars and trucks sold in the U.S.) The Acid Rain Program will reduce damage to materials by limiting SO2 emissions. The benefits of the Acid Rain Program are measured, in part, by the costs now paid to repair or prevent damage--the costs of repairing buildings and bridges, using acid-resistant paints on new vehicles, plus the value that society places on the details of a statue lost forever to acid rain.

To observe the effects of acid rain on marble and limestone, two building materials commonly used in monuments, ancient buildings, and in many modern structures:

- Place a piece of chalk in a bowl with white vinegar.
- Place another piece in a bowl of tap water.
- Leave the dishes overnight.

  The next day, see if you can tell which piece of chalk is more worn away.

This experiment with chalk allows you to see the effect of acid rain on marble and limestone because chalk is made of calcium carbonate, a compound occurring in rocks, such as marble and limestone, and in animal bones, shells, and teeth.

Effects of Acid Rain: Visibility Reduction

Sulfates and nitrates that form in the atmosphere from sulfur dioxide (SO2) and nitrogen oxides (NOx) emissions contribute to visibility impairment, meaning we can't see as far or as clearly through the air. Sulfate particles account for 50 to 70 percent of the visibility reduction in the eastern part of the United States, affecting our enjoyment of national parks, such as the Shenandoah and the Great Smoky Mountains. The Acid Rain Program is expected to improve the visual range in the eastern U.S. by 30 percent. Based on a study of the value national park visitors place on visibility, the visual range improvements expected at national parks of the eastern United States due to the Acid Rain Program's SO2 reductions will be worth over a billion dollars annually by the year 2010. In the western part of the United States, nitrates and carbon also play roles, but sulfates have been implicated as an important source of visibility impairment in many of the Colorado River Plateau national parks, including the Grand Canyon, Canyonlands, and Bryce Canyon.

Effects of Acid Rain: Human Health

Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Walking in acid rain, or even swimming in an acid lake, is no more dangerous than walking or swimming in clean water. However, the pollutants that cause acid rain (sulfur dioxide (SO2) and nitrogen oxides (NOx)) also damage human health. These gases interact in the atmosphere to form fine sulfate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs. Fine particles can also penetrate indoors. Many scientific studies have identified a relationship between elevated levels of fine particles and increased illness and premature death from heart and lung disorders, such as asthma and bronchitis.

Based on health concerns, SO2 and NOx have historically been regulated under the Clean Air Act, including the Acid Rain Program. In the eastern United States, sulfate aerosols make up about 25 percent of fine particles.By lowering SO2 and NOx emissions from power generation, the Acid Rain Program will reduce the levels of fine sulfate and nitrate particles and so reduce the incidence and the severity of these health problems.asthma and bronchitis. When fully implemented by the year 2010, the public health benefits of the Acid Rain Program are estimated to be valued at $50 billion annually, due to decreased mortality, hospital admissions, and emergency room visits.

Decreases in nitrogen oxide emissions are also expected to have a beneficial impact on human health by reducing the nitrogen oxides available to react with volatile organic compounds and form ozone. Ozone impacts on human health include a number of morbidity and mortality risks associated with lung inflammation, including asthma and emphysema.

Clean Air Markets Update

- **Clean Air Markets Update, Issue #4, Summer 2003**

  In this issue:
  - Distributing Allowances For Emission Trading Programs
  - Clearing the Air: Cap and Trade Q & A
  - Update on the U.S. Emission Trading Programs: New Report on Acid Rain and Surface Water
  - Program in Progress: The Dutch NOx Trading Program
  - U.S. Lessons Learned from Operating Emission Trading Registries
  - News from Around the World
  - Upcoming Events

- **Clean Air Markets Update, Issue #3, Winter 2002**

  In this issue:
  - Three Forms of Emissions Trading
  - The Ozone Transport Commission NOx Budget Program: A Model for the Creation of Mulit-Jurisdictional Emissions Trading Programs
  - E-Government and the Clean Air Markets Division
  - Sino-U.S. Cooperation on Cap and Trade
  - News from Around the World
  - Upcoming Events

- **Clean Air Markets Update, Issue #2, May 2002**

  In this issue:

- From the Desk of Brian McLean
- To Trade or Not To Trade?
- Emissions Trading Demonstration in Taiyuan, China
- Can Emissions Trading and Command-and-Control Regulations Coexist?
- Update on U.S. Emissions Trading Programs: Emissions Trading Goes On-Line
- Developing an Emissions Trading Program in Slovakia: A Case Study
- News From Around the World

- **Clean Air Markets Update, Issue #1, September 2001**

  In this issue:

  - Message from Brian McLean
  - The Environmental Case for Emissions Trading
  - Update on U.S. Emissions Trading Programs
  - Glossary of Trading-Related Terms in This Issue
  - Developing an Emissions Trading Program in Slovakia: A Case Study
  - News From Around the World
  - Domestic Emissions Trading Programs Around the Globe

The Update is available via regular postal mail upon request. We hope that you find the Clean Air Markets Update informative, and we invite you to submit comments, suggestions, news, and trading-related questions. We will try to address these submissions in subsequent issues of the Update, and we welcome the chance to open a dialogue with our readers. Please send feedback to the editor, at camu@epa.gov.

Forms For Clean Air Market Programs

- Acid Rain Program
- NOx Budget Trading Program
- These forms are also available from the CAMD Business System (CBS)

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- **Where to send the forms:**
  - **Street Address (Overnight mail and package delivery):**
    US EPA
    Clean Air Markets Division
    1310 L Street, NW
    Second Floor
    Washington, DC 20005
    Telephone: (202) 343-9494
  - **Regular or certified mail:**
    US EPA
    Clean Air Markets Division
    1200 Pennsylvania Avenue, NW
    Mail Code 6204J
    Washington, DC 20460
- Unless otherwise noted, forms are in Adobe Acrobat, which requires the free Acrobat Reader (the largest file is about 65K). Please see EPA's Acrobat page for more information about getting the reader. Files in WordPerfect are provided to allow completion using a computer.
- Forms that are not hyperlinked are available in hard copy only and may be ordered through the Acid Rain Hotline at (202) 564-9620.
- Check with your permitting authority before submitting these forms. It is possible that a state or local permitting authority may want to modify these forms and request that sources submit the state-modified versions only.

Acid Rain Program Forms

Allowance Forms

- Certificate of Representation Form: PDF | WordPerfect
- Allowance Transfer Form: Adobe Acrobat (file size: 53K) | WordPerfect (file size: 61K)
  (See note on single-signature requirement)
- Allowance Account Information Form: Adobe Acrobat (file size: 30K) | WordPerfect (file size: 56K)
  (Used for opening general accounts)

Acid Rain Program Home Page

The EPA SO2 Allowance Auction

ALLOWANCES AVAILABLE FOR THE 2004 EPA AUCTION (Updated 3/9/04):

Origin of Allowances	Spot Auction (First Usable in 2004)	7 Year Advance Auction (First Usable in 2011)
EPA	125,000	125,000
Privately Offered	11	
Total	**125,011**	**125,000**

- How to Bid Factsheet (32K Adobe Acrobat)
- Bid Form and Instructions (25K Adobe Acrobat)
- Offer Form and Instructions (25K Adobe Acrobat)
- Notification for Distribution of Proceeds from EPA Auctions
  (Used for changing recipient name on proceeds checks)
- Letter of Credit Form and Instructions (19K Adobe Acrobat)

Allowance Auctions Home Page

Acid Rain Permitting

- Phase II SO2 Permitting
  - Phase II Permit Application Form: PDF | WordPerfect
  - New Unit Exemption Form: PDF | WordPerfect
  - Retired Unit Exemption Form: PDF | WordPerfect
- Phase II NOx Permitting
  - Phase II NOx Compliance Plan: PDF | WordPerfect
  - Phase II NOx Averaging Plan: PDF | WordPerfect

Acid Rain Permits Home Page

Monitoring

- Certification/Recertification Application Form (EPA Form 7610-14): PDF

See the emissions monitoring home page for more information.

For information on all versions of the Electronic Reporting Format, see the emissions reporting home page.

Phase II Annual Reconciliation

- Phase II Annual Compliance Certification Report : WordPerfect | Adobe Acrobat
- Common Stack Allowance Deduction Form : WordPerfect | Adobe Acrobat
- Allowance Deduction Form : WordPerfect | Adobe Acrobat

Annual Reconciliation Fact Sheet

NOx Budget Trading Program

Allowance Forms

- Account Certificate of Representation Form: WordPerfect | Adobe Acrobat
- General Account Form: WordPerfect | Adobe Acrobat
- Allowance Transfer Form: WordPerfect | Adobe Acrobat

Compliance Forms

- Compliance Certification Report WordPerfect | Adobe Acrobat
- Common Stack Deduction WordPerfect | Adobe Acrobat
- Allowance Deduction WordPerfect | Adobe Acrobat

- Electronic Allowance Deduction File Instructions
- Electronic Allowance Deduction File : Excel Template

Permitting

- Sample Permit Application Form: MS Word | Adobe Acrobat
  (Official format available from the permitting authority)
- NOx State Implementation Plan (SIP) Call Home Page

Get Acrobat Reader Some of the documents provided by EPA are Adobe Acrobat PDF (Portable Document Format) files. For more information about PDFs, visit the About PDF page.

Workshops and Conferences of Interest

Upcoming

- None right now - check back soon!

Previously Held

- EPRI Presentations, May 3, 2004, Milwaukee, WI.
- EMA 8th Annual Spring Meeting, May 3-5 2004, New Orleans, Louisiana
- EMA 7th Annual Meeting and International Conference, September 21-23, 2003, Miami Beach, FL
- EPRI Presentations, May 2003
- US EPA Clean Air Market Programs Basic Workshops, 2002: Follow-up Materials

NOx Budget Trading Program (SIP Call)

- June 10, 2004 NOx SIP Call Monitoring and Reporting Workshop - Follow Up Materials
- NOx Sip Call Implementation workshops in Atlanta, Georgia, Chicago, Illinois, and Washington, D.C., 2003: Follow-up materials

- NOx Budget Program Workshops, 2001: Follow-up Materials and Guidance Documents

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A

acid deposition

The process by which acidic particles, gases, and precipitation leave the atmosphere. More commonly referred to as acid rain, acid deposition has two components: wet and dry deposition.

acid rain

The result of sulfur dioxide (SO2) and nitrogen oxides (NOx) reacting in the atmosphere with water and returning to earth as rain, fog, or snow. Broadly used to include both wet and dry deposition. The acid rain page provides a great deal of information about this issue.

Al

Aluminum; a metal that is toxic to trees and fish

allowance

A tradeable permit to emit a specific amount of a pollutant. For example, under the Acid Rain Program, one allowance permits the emissions of one ton of sulfur dioxide (SO2).

anions

Negatively charged molecule such as sulfate (SO4(2-)) and nitrate (NO3-). In combination with hydrogen (H+), these molecules act as strong acids.

acid neutralizing capacity (ANC)

A measure of the ability for water or soil to neutralize added acids. This is done by the reaction of hydrogen ions with inorganic or organic bases such as bicarbonate (HCO3-) or organic ions.

acidification

Refers to reducing something's pH, making it more acidic;

also means the loss of ANC.

adsorb

To take up and hold (a gas, liquid, or dissolved substance) in a thin layer of molecules on the surface of a solid substance.

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B

buffering capacity

The resistance of water or soil to changes in pH.

base cations

Positively charged ions such as magnesium, sodium, potassium, and calcium that increase pH of water (make it less acidic) when released to solution through mineral weathering and exchange reactions.

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C

Ca(2+)

Calcium; a base cation that helps to reduce acidification

chronic acidification

Generally refers to surface waters that remain acidified (ANC<0) regardless of variations in hydrologic conditions (precipitation, stream flow, etc.).

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D

deposition

The processes by which chemical constituents move from the atmosphere to the earth's surface. These processes include precipitation (wet deposition, such as rain or cloud fog), as well as particle and gas deposition (dry deposition).

dose response functions

The relationship between the effects (response) on an organism or system and the amount (dose) of some material to which the organism/system is exposed.

dry deposition

The settling of gases and particles out of the atmosphere. Dry deposition is a component of acid deposition, more commonly referred to as acid rain.

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E

eutrophication

A reduction in the amount of oxygen dissolved in water. The symptoms of eutrophication include blooms of algae (both toxic and non-toxic), declines in the health of fish and shellfish, loss of seagrass beds and coral reefs, and ecological changes in food webs.

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L

leaching

Process by which water removes chemicals from soil through chemical reactions and the downward movement of water.

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M

Mg(2+)

Magnesium; a base cation that helps to reduce acidification

mineral weathering

The physical and chemical breakdown of rocks that releases ions such as calcium and aluminum.

MW

Megawatt; a unit for describing how much electricity a power plant can generate. The Acid Rain Program includes virtually all units in the US that can generate over 25 MW.

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N

nitrogen fixation

The process in which bacteria convert biologically unusable nitrogen gas (N2) into biologically usable ammonia (NH3) and nitrates (NO3-).

nitrogen oxides (NOx)

A group of gases that cause acid rain and other environmental problems, such as smog and eutrophication of coastal waters. Burning fossil fuels, such as coal and gasoline, releases NOx into the atmosphere. Various programs are reducing NOx emissions, including the Acid Rain Program and NOx cap and trade programs.

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P

pH

A scale that denotes how acidic or basic a substance is. Pure water has a pH of 7.0 and is neither acidic nor basic. For more information, see the pH page.

precipitation

Water in the form of rain, sleet, or snow (wet deposition).

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S

sulfur dioxide (SO2)

A gas that causes acid rain. Burning fossil fuels, such as coal, releases SO2 into the atmosphere. Various EPA programs are reducing SO2 emissions, including the Acid Rain Program.

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W

wet deposition

The process by which chemicals are removed from the atmosphere and deposited on the Earth's surface via rain, sleet, snow, cloudwater, and fog.

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U.S. Environmental Protection Agency

Clean Air Markets

Site Map

This map shows where each major item or category fits into the site's sections. Generally speaking, the first four sections focus on EPA providing information, while "Doing Business With Us" provides tools for regulated units.

The site is color coded, and the major section buttons are shown below. Note that some items are linked from more than one place.

- Environmental Issues
- Programs & Regulations
- Progress & Results
- Allowance Trading
- Doing Business With Us

Environmental Issues

- Acid rain
  - What it is, how it's caused, how we measure it
  - Environmental and human health effects
  - What society can do
  - What individuals can do
  - Science experiments
  - Activities related to acid rain
  - Explanation of the pH scale
- Smog / Ozone Transport
- Regional Haze
- Climate Change

Programs and Regulations

- Acid Rain Program

    - Goals
    - Laws & regulations
    - Guidance & fact sheets
    - Information related to sulfur dioxide (SO_2) allowances
    - Program forms
    - Annual Reconciliation of allowances and emissions
    - Applicability determinations

- NOx Trading Programs
    - Summary table - quick description of the different programs
    - Ozone Transport Commission (OTC) NOx Budget Program
    - Section 126 Federal NOx Budget Trading Program / NOx State Implementation Plan (SIP) Call
- Monitoring Guidance (for all programs)

- Reporting Emissions (for all programs)

- Compliance Reports (for all programs)
- US Greenhouse Gas Inventory
- US - Canada Air Quality Agreement

Progress & Results

- Emissions Data
    - Emissions Scorecard
    - Preliminary summaries and raw hourly data
    - E-GRID: a downloadable database

- Compliance Reports

- Deposition Monitoring
    - Clean Air Status & Trends Network (CASTNET) Dry deposition monitoring
    - National Atmospheric Deposition Program (NADP) EXIT disclaimer Wet deposition monitoring; includes maps showing rainfall pH across the US (called isopleth maps)

- Acid Rain Program Progress Report
- National Acid Precipitation Assessment Report (NAPAP) "Biennial Report to Congress: an Integrated Assessment." May 1998 EXIT disclaimer
- Maps and Geographical Information System (GIS) Datasets
- Articles & Papers: academic reports written at an expert level

---

Emissions Trading

- Trading basics - a guide to how cap and trade works
- Buying allowances
  Learn the options for anyone to buy and sell allowances, including the Acid Rain Program allowance auctions
- Sulfur Dioxide (SO2) and Nitrogen Oxides (NOx) allowance & market data
  - Allowance Tracking Systems
    EPA's database of SO2 and NOx allowance accounts and transfers
  - SO2 market analysis
  - NOx market analysis
- Allowance allocations under the Acid Rain Program
  Information about how allowances are initially distributed to emission sources
- Compliance Reports
  Include information about allowance usage and "banked" allowances - amounts saved for future use
- Annual Reconciliation
  How EPA compares emissions and allowances under the Acid Rain Program

---

Doing Business With Us

These features are primarily intended for affected sources, so they tend to be written at a more expert level and do not provide a great deal of background information.

- Items specific to the Acid Rain Program
  - Submit an acid rain permit

  - Review Acid Rain Program Applicability Determinations
    legal decisions on how the regulations apply
  - Submitting Monitoring Plans and other Part 75 Requirements

- Items for all programs
  - Workshop information and materials
  - Register for a program; open an allowance account
  - Transfer allowances
  - Monitoring Guidance
  - Report emissions
  - Annual reconciliation
  - Allowance account query tools
  - Obtain forms

U.S. Environmental Protection Agency

Clean Air Markets

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EPA Home > Clean Air Markets > About the Clean Air Markets Division

Doing Business With Us

Programs and Regulations

Progress and Results

Allowance Trading

Reports and Articles

Data and Maps

Acid Deposition Monitoring

Environmental Issues

About the Clean Air Markets Division

- What is our Mission Statement?
- What is the Clean Air Markets Division?
- How is the Clean Air Markets Division organized?
- How can you contact us?

Our Mission Statement

Improve human health and the natural environment through the skillful design, operation and evaluation of cap-and-trade and other innovative programs that cost-effectively lower harmful air emissions and their deposition. Focus on lowering outdoor concentrations of fine particles, ozone, mercury and other significant air emissions through programs that offer regional, national, or international solutions to problems from air emissions. Often these programs will cover power plants and other major stationary sources, such as industrial boilers, but they will also consider other important sources of emissions. Goals of these programs include:

- High levels of health and environmental benefits
- Strong technical and analytic underpinning to ensure programs solve the problems that they address
- Accountability through sound monitoring and thorough reporting requirements that are continuously improved over time
- Highly effective market-based mechanisms
- Simplicity and practicality based on technical sophistication
- Clear communication
- Low administration costs
- Creating public access to emissions data from utilities (SO_2, NO_x, CO_2)
- High compliance rates

- Cost-effective emission reductions with reasonable economic impacts
- Customer service orientation, and
- Ongoing audits and evaluation to ensure health and environmental goals are met

---

What We Do

The Clean Air Markets Division manages various market-based regulatory programs designed to improve air quality.

We use experience gathered developing and operating the market-based Acid Rain Program to address other environmental problems. Specific efforts include:

- Designing and operating cap-and-trade programs to reduce emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x)
- Assessing emissions control technology options
- Emissions monitoring and reporting
- Conducting atmospheric deposition monitoring and analysis
- Developing information systems for market programs
- Assessing environmental and human health effects
- Assessing benefits and costs of programs
- Educating the public about acid rain, other regional air pollution problems, and market-based mechanisms
- Creating public access to emissions data from utilities (SO_2, NO_x, CO_2)

How We Are Organized

The Division has 4 organizational areas (called "Branches"). Much of our work crosses Branch boundaries.

- **Program Development**
  Chief: Sarah Dunham
  Develops cost-effective air pollution control programs that use market-based approaches and lessen the administrative burden for sources and regulators

- **Emissions Monitoring**
  Chief: Rey Forte
  Provides guidance to States and industry and ensures that emissions are accurately and cost-effectively measured and reported on time

- **Market Operations**

Chief: Janice Wagner
Performs the day-to-day functions required to operate market-based emission reduction programs, such as recording allowance transfers and receiving emissions reports, and works with stakeholders to ensure that the markets operate efficiently

- **Assessment and Communications**
  Chief: Rona Birnbaum
  Assesses the costs and benefits (environmental, human health, and economic) of the Division's programs and communicates this information to decision makers and other customers in a policy context

Doing Business With Us

Programs and Regulations

Progress and Results

Allowance Trading

Reports and Articles

Data and Maps

Acid Deposition Monitoring

Environmental Issues

Where to Start

This page provides common questions and links to answers. They are organized by audience. We have not included every possible question, so if you see a question that's similar to yours, try following that link. You can scroll down or follow a link below to see the questions for each audience.

- General public, including students & teachers
- Academic researchers
- Utility employees & people who work with them

General Public, Including Students & Teachers

What is acid rain? What causes it? How is it measured? What does it affect?
Start at the acid rain home page, where you'll find basic information and links to much more.

Where can I find maps of acid rain?
On the Web site for the National Atmospheric Deposition Program (NADP). EXIT disclaimer This network measures wet deposition, better known as acid rain, and produces maps of pH and other chemical characteristics of rain (the lower the pH, the more acidic; read more on the pH page). These maps are called isopleth maps.

What can I do to help solve acid rain?
Look over the items listed on the individual actions page. Also read what society as a whole can do about this problem.

How does allowance trading work?
Read the trading fact sheet.

How can my class buy SO2 allowances so they won't be emitted?
Read information about buying allowances.

Do you have experiments I can do about acid rain?

Yes! Read about them.

Do you have suggestions for activities, both inside the classroom and out?
Yes! Check the activities page.

How much sulfur dioxide (SO2), nitrogen oxides (NOx), and other gases do electric power plants emit (i.e., release) into the atmosphere?
Look at the various emissions reports and maps we offer.

Academic Researchers

What is acid rain and what are its effects?
Start at the acid rain home page.

Where can I find academic papers and more detailed articles?
Review our articles page and also look at the other information under the Progress & Results section.

How does allowance trading work?
Read the trading fact sheet.

How does EPA keep track of who owns what allowances?
Read about the allowance tracking system.

How do I find information about allowance accounts, how many allowances they hold, and allowance trades?
Use the query tools for the allowance tracking system.

What are the emissions from power plants?
Look at the information on the emissions page, including E-GRID, a comprehensive database that you can download.

Are companies complying with the regulatory programs?
Read annual compliance reports.

How do clean air market programs work?
Look at the home pages for each program:
Acid Rain Program | NOx trading programs

Utility Employees & People Who Work with Them

Where can I find the regulations that apply to each program?
Look under each program's home page:
Acid Rain Program | NOx trading programs

How do I query the allowance tracking system?

Use one of the online report forms.

What is necessary to comply with a program?
Visit the "Doing Business with Us" page.

How do I sign up to participate in a program?
Read how to register.

Where can I find forms for each program?
Generally, it's best to read about a particular activity; forms will be linked from there. Start with the "Doing Business with Us" page. If you know the specific form you need, look at the forms page.

How do I keep up with monitoring requirements?
Read the monitoring page, which includes information for each program.

How do I keep up with emissions reporting requirements?
Check the reporting page, which includes information for each program.

U.S. Environmental Protection Agency

Clean Air Markets

Related Web Sites

This information is provided as a service; EPA does not endorse, approve, or otherwise support these non-EPA sites.

EXIT disclaimer indicates links to non-EPA sites; when shown next to a heading, all links in that category are non-EPA sites.

We would appreciate hearing about other resources related to Acid Rain and our programs. Thanks.

Acid Rain

General

EPA Air Quality Trends Reports
NAPAP Tracking and Analysis Framework EXIT disclaimer
National Atmospheric Deposition Program/National Trends Network EXIT disclaimer
U.S. Geological Survey: Acid rain monitoring EXIT disclaimer

Environmental Effects

National Park Service - Air Related Issues EXIT disclaimer
Environmental Monitoring and Assessment Program (EMAP)

International

Environment Canada's Acid Rain site EXIT disclaimer
UN Convention on Long-Range Transboundary Air Pollution EXIT disclaimer
Transboundary Air Pollution Research in Europe and Asia EXIT disclaimer
State of the Environment Norway - Acidification EXIT disclaimer

Emissions Trading

Emissions Trading Education Initiative EXIT disclaimer
Tradeable Permits Bibliography EXIT disclaimer
Ozone Transport Assessment Group (OTAG)

RECLAIM EXIT disclaimer
Emissions Marketing Association EXIT disclaimer
Michigan Dept. of Environmental Quality -- Emissions Credit Trading EXIT disclaimer

Emissions Trading and Climate Change

EPA's Climate Change site
State Department's Climate Change Site EXIT disclaimer
United Nations Framework for Climate Change EXIT disclaimer
Organization for Economic Cooperation and Development (OECD) EXIT disclaimer

Resources for the Future EXIT disclaimer
Environmental Defense Fund EXIT disclaimer
World Resources Institute EXIT disclaimer

Electric Utility Information

Electric Power Research Institute (EPRI) EXIT disclaimer
Energy Information Administration EXIT disclaimer
National Association of Regulatory Utility Commissioners (NARUC) EXIT disclaimer

Environmental Technology

Air and Waste Management Association EXIT disclaimer
U.S. EPA - Air Pollution Technology Branch

Renewable Energy

The Source for Renewable Energy EXIT disclaimer
U.S. DOE - Energy Efficiency and Renewable Energy Network EXIT disclaimer
Solstice Center for Renewable Energy and Sustainable Technology EXIT disclaimer

U.S. Environmental Protection Agency

Privacy and Security Notice

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Privacy and Security Notice

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- the date and time
- the originating Internet Provider address (IPA) (this address can refer to a specific computer; more frequently, commercial Internet providers use a temporary IPA which does not link to a specific computer)
- the type of browser and operating system used (if provided by the browser)
- the URL of the referring page (if provided by the browser)
- the object requested
- completion status of the request
- pages visited

We use the information that we automatically collect to measure the number of visitors to the different areas of our sites, and to help us make our pages more useful to visitors. This includes analyzing these logs periodically to determine the traffic through our servers, the number of pages served, and the level of demand for pages and topics of interest.

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- businesses use them for customer convenience to allow them to produce a list of items to buy and pay for them all at one time and to garner information about what individuals are buying at their sites;
- advertisers use them to determine the effectiveness of their marketing and offer insights into consumer preferences and tastes by collecting data from many Web sites; and
- they can be used to help a Web site tailor screens for each customer's preference.

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- what information is to be collected;
- the intended use of the information;
- how it will be protected/secured;
- if it will be shared within or outside EPA, including on publicly available Web sites;
- if shared, with whom;
- the opportunity to consent to, or reject, the collection and/or sharing, and

- when it will be destroyed.

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The Act s major provisions require agencies to:

- publish a Privacy Act Notice in the Federal Register explaining the existence, character and uses of a new or revised SOR;
- keep information about you accurate, relevant, timely, and complete to assure fairness in dealing with you; and
- allow you to, upon request, access and review your information held in a SOR and request amendment of the information if you disagree with it.

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Search frequently asked questions or submit your own questions or comments.

Content updated July 2004

U.S. Environmental Protection Agency

Clean Air Markets - Programs and Regulations

Recent Additions | Contact Us | Print Version Search:

GO

EPA Home > Clean Air Markets > Programs and Regulations > NOx Trading Programs

Home | Business | Programs | Progress | Trading | Reports | Data and Maps | Monitoring | Issues

Acid Rain Program
NOx Trading Programs
Monitoring
US - Canada

NOx Trading Programs

- Overview of All Programs
- Program Home Pages
  - Ozone Transport Commission (OTC) NOx Budget Program
  - NOx State Implementation Plan (SIP) Call

Overview of NOx Trading Programs

All NOx trading programs have the same goal: reduce the transport of ground-level ozone across large distances. However, the programs have different developed through different mechansisms, which has led to differences in the number of states involved, the timing of the compliance period each year, and the expected reductions.

Detailed information is available on the home page for each program, but the following table summarizes the key differences:

	Ozone Transport Commission (OTC) NOx Budget Program	NOx State Implementation Plan (SIP) Call
States Covered	CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT	AL, CT, DC, DE, IL, IN, KY, MA, MD, MI, NC, NJ, NY, OH, PA, RI, SC, TN, VA, WV (Phase 1); GA, MO (Phase 2)
Compliance Period	May 1 - September 30 of each year	May 1 - September 30 of each year (In 2004 the compliance period begins May 31.)
Initial Compliance Year	1999	2003/2004 (Phase 1); 2007 (Phase 2)

Emissions Cap	219,000 tons in 1999; 143,000 tons in 2003	
Baseline Year	1990	1995
Baseline Emissions	490,000 tons	
Program Owner	OTC; Allowances set by OTC, program administered by EPA	States and EPA; States have the option of participating in the trading program and establishing unit allocations, program administered by EPA

What is pH?

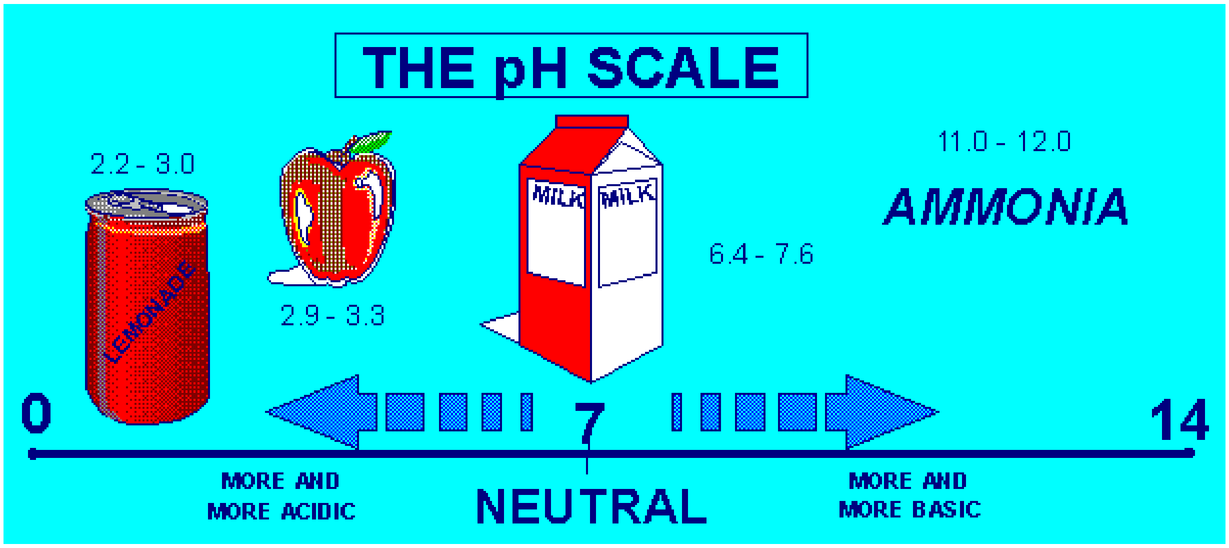
Acidic and basic are two extremes that describe chemicals, just like hot and cold are two extremes that describe temperature. Mixing acids and bases can cancel out their extreme effects, much like mixing hot and cold water can even out the water temperature. A substance that is neither acidic nor basic is neutral.

The pH scale measures how acidic or basic a substance is. It ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is basic. Each whole pH value below 7 is ten times more acidic than the next higher value. For example, a pH of 4 is ten times more acidic than a pH of 5 and 100 times (10 times 10) more acidic than a pH of 6. The same holds true for pH values above 7, each of which is ten times more alkaline (another way to say basic) than the next lower whole value. For example, a pH of 10 is ten times more alkaline than a pH of 9.

Pure water is neutral, with a pH of 7.0. When chemicals are mixed with water, the mixture can become either acidic or basic. Vinegar and lemon juice are acidic substances, while laundry detergents and ammonia are basic.

Chemicals that are very basic or very acidic are called "reactive." These chemicals can cause severe burns. Automobile battery acid is an acidic chemical that is reactive. Automobile batteries contain a stronger form of some of the same acid that is in acid rain. Household drain cleaners often contain lye, a very alkaline chemical that is reactive.

The following diagram shows the pH scale and the pH of some common items:



La. Department of Environmental Quality

Search for:

GO

The Ozone Forecast

THE BATON ROUGE AREA

Sun	Mon	Tue
AQI: 34	AQI: 59	AQI: 51

Issued: 12:05PM,SUN AUG 29 2004

THE SHREVEPORT AREA

Sun	Mon	Tue
AQI: 34	AQI: 41	AQI: 41

Issued: 12:05PM,SUN AUG 29 2004

THE NEW ORLEANS AREA

Sun	Mon	Tue
AQI: 39	AQI: 48	AQI: 46

Issued: 12:05PM,SUN AUG 29 2004

AIR QUALITY INDEX

0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for Sensitive Groups
151 to 200	Unhealthy

Click Here For Complete Forecast

Category Listings

All About DEQ

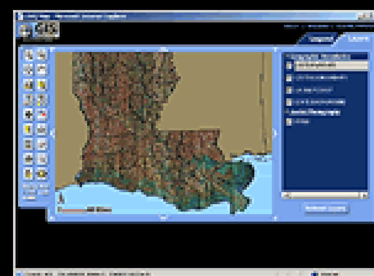
- organizational charts
- addresses and phone numbers
- email addresses
- employment
- more...

Reformulated Gasoline (RFG)

FAQ on Gasoline Changeover

Sec. McDaniel's Letter to EPA

The GIS Center



Click here

- **Educational Resources**
- **Alphabetical Listing**
- **Forms**
- **Publications**
- **Informational Fact Sheets**
- **Data**
- **Media** (air, water, etc.)
- **Public Records/EDMS Status**

Hg Mercury Information

- Louisiana Services Directory
- Info Louisiana
- Other Sites of Interest

Key Subject Areas

- **News** - public notices, news releases & environmental contamination notices, Louisiana Environmental Update publication.
- **Assistance** - customer assistance, education, small business, outreach, estuary program, complaints, community relations, hotlines, recycling, waste minimization, waste tires, litter, RCRIS Manifests
- **Rules and Regulations** - Title 33 regulations, proposed rules, emergency rules, electronic subscription, environmental quality act, Where do I send my information
- **Motor Vehicle Inspection / Maintenance Program** - motor vehicle emissions and air pollution, maintaining vehicle to reduce emissions, on-board diagnostics, qualified inspection stations, FAQs
- **Permits** - applications, permits, authorizations, certifications, licenses, forms, permit guidance documents
- **Surveillance** - single point of contact for reporting spills & complaints, emergency response, water quality, atrazine study, mercury study, gasoline spill, EWOCDS, chemical accident prevention, radiological emergency planning and response, smoke school
- **Enforcement** - activity reports, sample DMR forms, Beneficial Environmental Projects
- **Planning** - strategic planning, regulation development, water quality management plan/continuing planning process, water quality inventory, fishing & swimming advisories, nonpoint source pollution, environmental managements systems, ISO standards
- **Evaluation** - environmental indicators, watershed surveys, TRI, aquifers, emission inventory, air monitoring, source water assessment, drinking water protection, ozone, Today's Ozone Forecast, Near Real-Time AQI Levels
- **Technology** - RECAP, stack testing, Total Maximum Daily Load Program (TMDL), Ground Water Certification, Ready for Reuse
- **Remediation** - superfund, voluntary cleanup, inactive and abandoned sites, underground storage tanks
- **Laboratory** - accreditation, radon
- **Financial Matters** - state revolving loan program, UST trust fund, grants, contracts, waste tires
- **Geographical Information Systems** - make a map

Send e- mail to webmaster@deq.state.la.us or any member of our WWW Task Force
with questions or comments about this web site. To contact us by phone or mail,
see our Office Address/Phone listing.

What is New?

Home | What is New? | Events / Notices | Search | About This Site | Your Comments

A listing of new and updated items on the Louisiana Department of Environmental Quality website and the dates that these changes took place.

Forms Publications Data Information Fact Sheets

Last Updated: 20-Aug-04 09:03 am

Aug-20

Calendar of Events / Notices (Daily)
E-mail Addresses for DEQ (Daily)
Forms Index (Daily)
Media Index (Daily)
Public Notices (Daily)
What's New (Daily)

Aug-16

UST Installation/Upgrade/Renovation Notification Form NEW

Jul-01

Local Drinking Water Programs NEW

Environmental Regulatory Code Order Form (PDF) Updated

Jun-30

Title 33 - Environmental Quality Regulations & Supplements Updated

Jun-29

Calcasieu Special Project Monitoring Data Updated

Jun-23

5-Year Strategic Plan 2005-2010 NEW

Jun-21

Delatte Metals Superfund Site Op & Maint Plan NEW

Ambient Air Monitoring Sites Updated

Ambient Monitoring Schedule Updated

Early Warning Organic Compound Detection System - Compounds Updated

Excursion Form for NPDES permit limit exceedances (MSWord) Updated

I/M Similar State Programs Updated

Louisiana Water Quality Management Plan - Volume 1 (pdf) Updated

On Board Diagnostics Updated

RECAP Frequently Asked Questions Updated

RECAP Frequently Requested Files Updated

Radiation Industrial Radiography License Guide and Application - Afterloader Updated

Radiation Industrial Radiography License Guide and Application - Eye Applicator Updated

Recycling Directory - by commodity Updated

Recycling Directory - by commodity (MS Excel) Updated
Air Monitoring Program Description (editorial changes)

Jun-17

Disposal Sites Accepting Asbestos Containing Waste - Friable (Excel) NEW

Disposal Sites Accepting Asbestos Containing Waste - Friable (PDF) NEW

Disposal Sites Accepting Asbestos Containing Waste - Non-Friable (Excel) NEW

Disposal Sites Accepting Asbestos Containing Waste - Non-Friable (PDF) NEW

Chemical Accident Prevention Program Registration Requirements and Form Updated

LPDES Water Discharge Permit Applications Updated
LPDES Water Discharge Permit Applications Cement, Concrete, and Asphalt Facilities (CCAF-GP) Updated

LPDES Water Discharge Permit Applications All Industrial (SCC-2) Updated

LPDES Water Discharge Permit Applications Automotive Repair Facilities (ARB-G) Updated

LPDES Water Discharge Permit Applications Barge Cleaning and/or repair (WPC-3) Updated

LPDES Water Discharge Permit Applications Bulk petroleum and transfer facilities (BST-2) Updated
LPDES Water Discharge Permit Applications Dewatering of Underground Storage Tank... (USTGWR-G) Updated
LPDES Water Discharge Permit Applications Exterior Vehicle and Equipment Wash Facilities (CW-G) Updated

LPDES Water Discharge Permit Applications Hydrostatic test (HST-G) Updated

LPDES Water Discharge Permit Applications Light Commercial General (LCF-G) Updated

LPDES Water Discharge Permit Applications Natural gas compressor stations (NGF-3) Updated

LPDES Water Discharge Permit Applications Sand and Gravel Extraction Facilities (SCC-3) Updated
LPDES Water Discharge Permit Applications Sanitary dischargers < 100,000 gallon/day (WPS-G) Updated

LPDES Water Discharge Permit Applications Sanitary wastewater >= 100,000/day (WPS-S) Updated

LPDES Water Discharge Permit Applications Seafood processing shrimp shellfish .... (WPC-5) Updated

Lead Accreditation Application Form (PDF) Updated

Lead Accreditation Application Instructions Updated

Lead Contractor Letter of Approval Application for Commercial & Industrial Lead Removal Form (pdf) Updated

Lead Contractor Letter of Approval Application for Commercial & Industrial Lead Removal Instructions Updated

Lead Contractor Letter of Approval for Target Housing and Child-Occupied Facility Lead Removal Form Updated

Lead Contractor Letter of Approval for Target Housing and Child-Occupied Facility Lead Removal Instr Updated

Lead Project Notification Form (pdf) Updated

Lead Testing Information Updated

Reciprocity Form (PDF) Updated

Reciprocity Form (Word) Updated

UST Certified Workers Updated

UST Certified Workers (MSExcel) Updated

UST Continuing Education Courses Updated

UST Motor Fuel Delivery Certificate List - alphabetical Updated

Jun-08

Mercury Program Updated

May-27

Drinking Water Ordinances NEW

Drinking Water Protection Committees NEW

Drinking Water Protection Glossary NEW

Drinking Water Protection Glossary NEW

Drinking Water Protection Links NEW

Drinking Water Protection Program NEW

Drinking Water Protection Program - About the program NEW

Drinking Water Protection Program Contacts NEW

Drinking Water Protection Resources NEW

Drinking Water Protection Resources for Kids NEW

Drinking Water Protection Team NEW

Hazardous Waste Combustion NEW

How do we protect drinking water? NEW

Where does drinking water come from? NEW

Why should we protect drinking water? NEW

Brownfields Pilots Contact Information Updated

Ground Water Baseline Monitoring Project Updated

May-24

Lead Training Providers (MSExcel) NEW

Lead Training Providers (PDF) NEW

Toxics Release Inventory 2002 NEW

Enforcement Activity Reports Updated

Environmental Quality Act (PDF) Updated

Environmental Regulatory Code Availability Updated

Lead Accredited Inspectors Updated

Lead Accredited Project Designers Updated

Lead Accredited Public Entities Updated

Lead Accredited Risk Assessors Updated

Lead Accredited Supervisors Updated

Lead Accredited Workers Updated

Technology Submittals Updated

May-05

Waste Tire Location Questionnaire Form Updated

All pages herein best if read using MS Internet Explorer or Netscape version 6 or greater.

[Home]

Send e- mail to webmasterdeq@LA.GOV or any member of our WWW Task Force
with questions or comments about this web site. To contact us by phone or mail,
see our Office Address/Phone listing.

Events / Notices

Last updated on 29-Aug-04 05:50 pm

August 2004

Mon, Aug-30

TRAINING: CAPACITY, MANAGEMENT, OPERATIONS & MAINTENANCE (CMOM) - An Exchange of Practical Experiences Among EPA, the States and the Municipalities. To be held in Austin, TX. See the brochure.

Tue, Aug-31

CONFERENCE: EPA LANDFILL GAS TO ENERGY CONFERENCE - Registration required (see link below. Use conference code EPA65006) Agenda

8:00 AM - 5:00 PM Tuesday, August 31, 2004 Galvez Building Conference Center 602 N. Fifth Street, Baton Rouge, LA 70802 Register for Conference EPA65006

PUBLIC HEARING: PUBLIC HEARING:CONOCOPHILLIPS COMPANY/ALLIANCE REFINERY - Public hearing on the draft hazardous waste CAMU/Post-Closure Permit 6:00pm Belle Chasse Auditorium, 8398 Highway 23, Belle Chasse More Information

September 2004

Mon, Sep-06

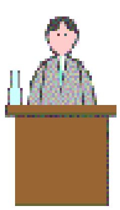
HOLIDAY

LABOR DAY

Wed, Sep-08

PUBLIC HEARING: PUBLIC HEARING: ENTERGY NEW ORLEANS, INC. - MICHOUD ELECTRIC GENERATING PLANT - Public hearing on the proposed Part 70 Air Operating Permit, Modification & Renewal Of The Acid Rain Permit, Prevention of Significant Deterioration (PSD) Permit and the associated Environmental Assessment Statement (EAS) 6:00pm City Hall, Council of Chambers located at 1300 Perdido Street, New Orleans, LA 70112 More Information

Thu, Sep-09

WORKSHOP:  **ANNUAL ASBESTOS/LEAD WORKSHOP** - Members of the DEQ asbestos and lead staff will address changes in the rules, topics of interest and/or concern, and new asbestos fees which became effective on July 1, 2003. 8:30am-12:00pm in the Galvez building auditorium located at 602 N. Fifth Street, Baton Rouge, LA 70802. More information. For assistance, contact Nick Harmon at (225) 219-3026.

Wed, Sep-15

DEADLINE: **SUBMIT NEW RESPONSE ACTION CONTRACOTR APPLICATIONS FOR QUARTERLY RAC LISTING**

CONFERENCE: **2ND ANNUAL KEEP LOUISIANA BEAUTIFUL STATE CONFERENCE** - Awards Brochure Septemper 15-17, 2004 Riverfront Center 707 Main Street, Alexandria, Louisiana Conference Brochure

PUBLIC HEARING: **PUBLIC HEARING: MONSANTO COMPANY / EMA SETTLING BASIN & NO. ONE WELL POND** - Public hearing on a draft hazardous waste post-closure permits modifications 6:00pm St. Charles Parish Council Chamber, 15045 Louisiana Highway 18 (River Road), Hahnville More Information

Fri, Sep-24

PUBLIC HEARING: **PUBLIC HEARING: FOR PROPOSED RULES HWO86, UT011, AND WQ056** -

Thu, Sep-30

EXAM: **INDUSTRIAL RADIOGRAPHY EXAM** - Deadline to Register is August 26, 2004. A DRC20 form and a check or money order made out to LDEQ for $178.00 are required to register for the exam. More information. For assistance, contact Tabitha Rice (225) 219-3027.

October 2004

Fri, Oct-01

DEADLINE: **DEADLINE: FOR COMMENTS ON PROPOSED RULES HWO86, UT011, AND WQ056** -

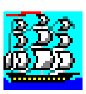
Tue, Oct-05

EXAM: **UST WORKER CERTIFICATION** - Installation/Repair Exam 8:30am. Closure Exam 1:00pm.

Thu, Oct-07

PUBLIC HEARING: **PUBLIC HEARING (10:00 AM IN SHREVEPORT, LA): FOR COMMENTS ON SHREVEPORT-BOSSIER CITY EARLY ACTION COMPACT SIP REVISION** -

Mon, Oct-11


COLUMBUS DAY (OBSERVED) - This is NOT a state holiday.

Tue, Oct-12

TRAINING: **SMOKE SCHOOL (CLASSROOM TRAINING)** - 8:00 - 12:00 DEQ HQ Room C-110 & C-111 For assistance, contact Evita Lagard @ (225) 219-3600

TRAINING: **SMOKE SCHOOL (FIELD TESTING AND CERTIFICATION)** - 7:30 - 8:00 am Registration 8:00 - 11:00 am Testing North Sherwood Forest BREC Park located @ 3140 North Sherwood Forest Blvd, Baton Rouge LA For assistance, contact Evita Lagard @ (225) 219-3600

Thu, Oct-14

DEADLINE: **DEADLINE: FOR COMMENTS ON SHREVEPORT-BOSSIER CITY EARLY ACTION COMPACT SIP REVISION** -

Fri, Oct-15

TRAINING: **SMOKE SCHOOL (FIELD TESTING AND CERTIFICATION MAKE-UP ONLY)** - 7:30 - 8:00 am Registration 8:00 - 11:00 am Testing North Sherwood Forest BREC Park located @ 3140 North Sherwood Forest Blvd, Baton Rouge LA For assistance, contact Evita Lagard @

(225) 219-3600

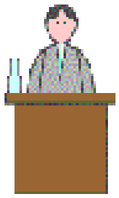
Wed, Oct-20

TRAINING: SOLID WASTE OPERATOR TRAINING (OCT 20-21, 2004) - At the Holiday Inn I-20, 102 Lake Street, Shreveport, LA. Mor e Information. For assistance, contact Suzanne Bordelon at (225)219-3030.

Thu, Oct-21

EXAM: SOLID WASTE OPERATOR EXAM - At the Holiday Inn I-20, 102 Lake Street, Shreveport, LA. Mor e Information. For assistance, contact Suzanne Bordelon at (225)219-3030.

Fri, Oct-22

CONFERENCE:  **LOUISIANA SOCIETY OF CERTIFIED PUBLIC MANAGERS** - To be held at the Lod Cook Conference Center at LSU.

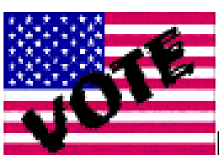
Sun, Oct-31

DAYLIGHT SAVINGS TIME ENDS - Remember to set your clock BACKWARD one hour. You don't want to miss that extra hour of sleep.

November 2004

Tue, Nov-02

HOLIDAY



ELECTION DAY

Thu, Nov-04

DEADLINE: INDUSTRIAL RADIOGRAPHY EXAM TO HELD ON DEC 9 - Deadline to Register is November 4, 2004. A DRC20 form and a check or money order made out to LDEQ for $178.00 are required to register for the exam. More information. For assistance, contact Tabitha Rice (225) 219-3027.

Thu, Nov-11

HOLIDAY

Thu, Nov-25

HOLIDAY

THANKSGIVING DAY

Fri, Nov-26

ACADIANA DAY (MUST BE DECLARED)

December 2004

Thu, Dec-02

EXAM: UST WORKER CERTIFICATION - Installation/Repair Exam 8:30am. Closure Exam 1:00pm.

Thu, Dec-09

EXAM: INDUSTRIAL RADIOGRAPHY EXAM - Deadline to Register is November 4, 2004. A DRC20 form and a check or money order made out to LDEQ for $178.00 are required to register for the exam. More information. For assistance, contact Tabitha Rice (225) 219-3027.

Wed, Dec-15

DEADLINE: SUBMIT NEW RESPONSE ACTION CONTRACOTR APPLICATIONS FOR QUARTERLY RAC LISTING

Fri, Dec-24

HOLIDAY

CHRISTMAS

January 2005

Tue, Jan-11

TRAINING: SMOKE SCHOOL (FIELD TESTING AND CERTIFICATION) - 7:30 - 8:00 am Registration 8:00 - 11:00 am Testing @ Lake Bistineau State Park, Group Camp 2 For assistance, contact Evita Lagard @ (225) 219-3600

Thu, Jan-13

TRAINING: SMOKE SCHOOL (FIELD TESTING AND CERTIFICATION MAKE-UP ONLY) - 7:30 - 8:00 am Registration 8:00 - 11:00 am Testing @ Lake Bistineau State Park, Group Camp 2 For assistance, contact Evita Lagard @ (225) 219-3600

March 2005

Wed, Mar-02

CONFERENCE: DEQ'S ANNUAL ENVIRONMENTAL CONFERENCE - For assistance, contact Leslie Garcia at leslie.garcia@la.gov or (225)219-3272.

April 2005

Sun, Apr-03

DAYLIGHT SAVINGS TIME BEGINS - Remember to set your clock FORWARD one hour. You don't want to be late for everything.

Tue, Apr-12

TRAINING: SMOKE SCHOOL (CLASSROOM TRAINING) - 8:00 - 12:00 DEQ HQ Room C-110 & C-111 For assistance, contact Evita Lagard @ (225) 219-3600

TRAINING: SMOKE SCHOOL (FIELD TESTING AND CERTIFICATION) - 7:30 - 8:00 am Registration 8:00 - 11:00 am Testing North Sherwood Forest BREC Park located @ 3140 North Sherwood Forest Blvd, Baton Rouge LA For assistance, contact Evita Lagard @ (225) 219-3600

Fri, Apr-15

TRAINING: SMOKE SCHOOL (FIELD TESTING AND CERTIFICATION MAKE-UP ONLY) - 7:30 - 8:00 am Registration 8:00 - 11:00 am Testing North Sherwood Forest BREC Park located @ 3140 North Sherwood Forest Blvd, Baton Rouge LA For assistance, contact Evita Lagard @ (225) 219-3600

Search

Enter Keyword(s):

[ ] Search

☐ Plain English Search.

Send e- mail to webmaster@deq.state.la.us or any member of our WWW Task Force
with questions or comments about this web site. To contact us by phone or mail,
see our Office Address/Phone listing.

About This Site

Our web site is arranged to follow our organizational design for the most part. We hope that you are able to find what you are looking for, but if not, maybe we can help you with this description of some of the options that are available.

Finding what you are looking for:

We have tried to come up with several different ways to find what you are looking for. There is an **alphabetical listing** of all of our articles, which was called the Index of Topics on our old web site. There is also an alternate listing by **media**. In conjunction with this, there are several other listings of **forms, publications**, **data**, and **informational fact sheets**. Another variation on this theme is the **site map** which shows all of the articles in an outline form based on where they are and how they are linked together. There is also a **search form**, which allows you to key in the information you are seeking and it will find the article for you.

Finding out what's going on:

The **What's New** page lists all changes and additions to our page over the last couple of months and when those changes or additions took place. The **Events/Notices** page lists most all events (conferences, meetings, deadlines, training, hearings) and notices (general announcements). The **News Releases** page lists all news releases and public notices.

Getting assistance:

If you have questions or need assistance with any of our pages, please feel free to contact any member of our **WWW Task Force**. If you would rather contact us in person or on the phone, please refer to our **Office Address and Phone Listing**. If you need the e-mail address for a division at DEQ, please refer to our **Email** page.

Comments and suggestions:

We are continuously striving to improve and update our web site and would love to hear your **comments and suggestions**. In the past, we have found those suggestions very helpful and they have led to some of our most popular pages.

Send e- mail to webmaster@deq.state.la.us or any member of our WWW Task Force
with questions or comments about this web site. To contact us by phone or mail,
see our Office Address/Phone listing.

Your Comments

We really do welcome any comments, suggestions, questions, etc. that you may have. The results of our feedback are discussed at the monthly meeting of our WWW Task Force. There are already several items that have been placed on our page as a direct result of requests from the public. We are doing our best to get you the information that you need so please let us know what we are doing well and what we could do better. We need your input!

Feel free to send e-mail to our **webmaster@deq.state.la.us**, any member of our **WWW Task Force**, or any **Division** here at DEQ. There is also a listing of the **address and phone number** of each of our offices if you wish to contact us by letter or telephone.

We welcome all of your comments and suggestions.

Send e- mail to webmaster@deq.state.la.us or any member of our WWW Task Force
with questions or comments about this web site. To contact us by phone or mail,
see our Office Address/Phone listing.

Water Cycle

Water Cycle

Water is the most important substance on the earth. It's the basis of life on our planet. It cycles through Earth's various systems just like blood cycles through our bodies.

BACKGROUND

Do you remember how the water cycle works? The sun's energy causes water to evaporate from the earth's surface. This process forms water vapor in the atmosphere. As water vapor rises, it cools and becomes a liquid again. This is called condensation. The condensed liquid returns to the earth as precipitation. If you've ever watched those huge cumulonimbus clouds gather over Lake Pontchartrain on a summer day, you probably weren't surprised by the afternoon showers that followed!

Rain showers like that are common in a large watershed like the Lake Pontchartrain Basin.

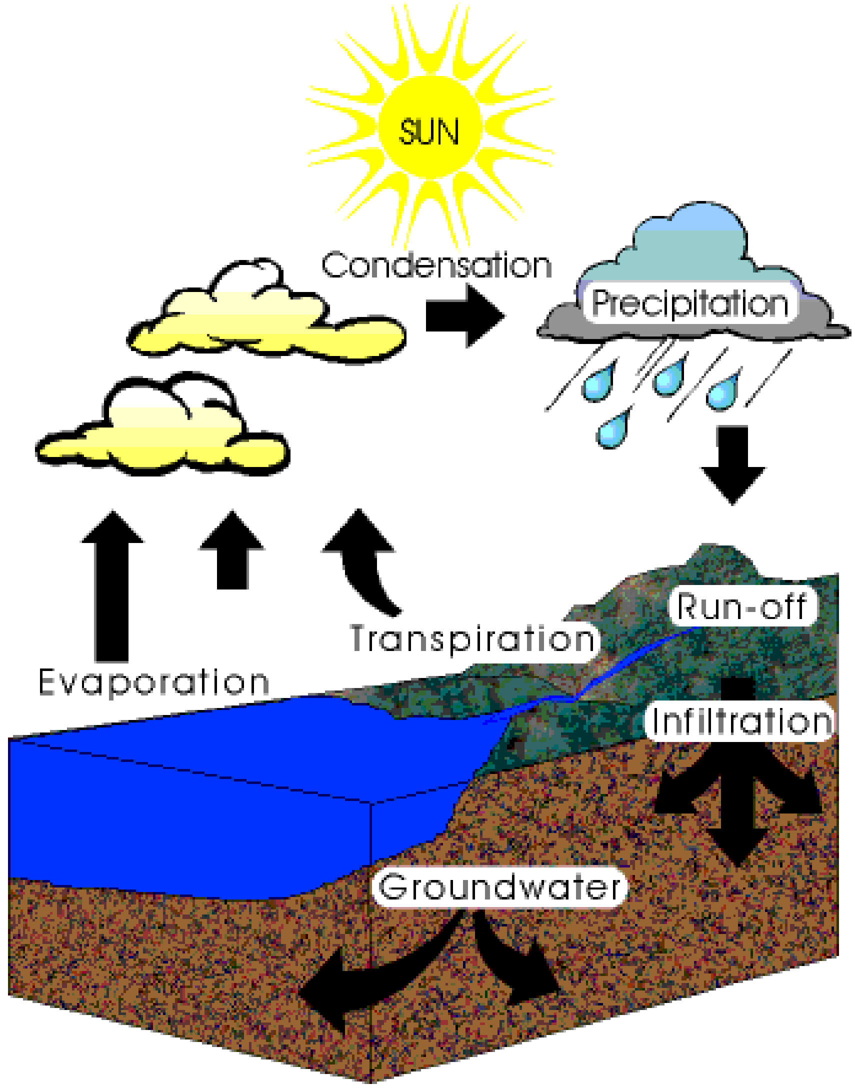
What Happens To All That Precipitation?

- Some of it is used by plants and animals in the Basin. The process of water intake and then breathing out or releasing moisture-laden air is called *transpiration*. . . . .

- Some soaks into the ground and becomes part of the water table or an aquifer in the process known as *infiltration*. . . . . .

- Some enters lakes, streams, and rivers as *runoff*. . . . .

- *Evaporation* from surface water occurs again, and the cycle is complete.



In summary, the *Water Cycle* recycles the earth's water supply over and over!

ACTIVITY

To demonstrate the water cycle, each person in your group or class can play the role of a water molecule passing through the cycle. Try this activity:

Water Cycle Walk

1. On poster paper or butcher paper, make a sign for each stage of the water cycle: sun, cloud, precipitation *(rain, hail, snow, sleet)*, surface water *(lake, river, stream)*, and groundwater. Make signs to represent water use by plants and animals in transpiration also. Place each in an open space in the center of the classroom, ***(see diagram)***.

2. On poster paper or butcher paper, make directional arrows to represent each process of the water cycle: evaporation, condensation, runoff, infiltration, transpiration *(one each for plant and animal use)*. Place each arrow in its appropriate spot on the floor between two

water cycle stages, ***(see diagram)***.

3. Have students represent water molecules *(perhaps wearing ball caps with the brim tilted up, labeled H2O)* and have them do the "Water Cycle Walk" in small groups.

4. Play a tape of music with sounds of a stream, thunderstorm or ocean. After 10-15 seconds, stop the music as a signal for students to stand still. Each student can either explain the stage of the water cycle on which he/she is standing, or can respond to questions about the water cycle.

5. Repeat with remaining groups of students.

Adapted from Lake Pontchartrain Basin Foundation lesson plans

[Home] [Up] [Water Cycle] [Water Use] [Water Quality] [Water Pollution]

Water Use

Water Use

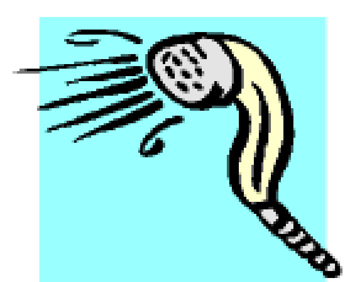
BACKGROUND

Water is all around us. It gushes from our faucets and showers and drinking fountains. We use it so frequently and casually that we take it for granted.

Do you know the source of tap water in Lake Pontchartrain Basin? On the north shore of the lake, it comes from the north shore aquifers. Water for Orleans and Jefferson parishes is drawn from the Mississippi River. What's the source of the tap water in your community? **Here in the United States, each person uses about 100 gallons of water every day.** What impact does that have on water quality?

Take this quick quiz and see!

1. Do you allow water to run when **brushing teeth** or **washing dishes**?
   Or
   Do you run the water only when rinsing?
2. Do you **wash your cars or pets** on a concrete surface?
   Or
   Do you wash them over a grassy area?
3. Do you **let the water hose run** unnecessarily when working outdoors?
   Or
   Do you control the flow with a water nozzle?
4. Do you **waste water by flushing** tissues or hair down



the toilet?
Or
Do you save water and dispose of those things in a trash can?

Now your turn! Using the following chart, try to estimate your family's water use for a day.

ACTIVITY

Daily Water Use Chart

WATER USE	AVERAGE AMOUNT USED	FAMILY WATER USE
drinking water	6-8 ounces per glass	____________________
making beverages	32 ounces per quart	____________________
flushing toilets	3-5 gallons per flush	____________________
taking a shower	5 gallons per minute	____________________
taking a bath	35-40 gallons	____________________
washing dishes	10-15 gallons	____________________
doing laundry	19-45 gallons	____________________
washing hands	32 ounces	____________________
brushing teeth	1 gallon	____________________
washing car	20-30 gallons	____________________
watering lawn	240 gallons/half hour	____________________

HOW DO YOU THINK YOU AND YOUR FAMILY MEASURE UP?

LET'S CHECK !

To calculate the amount of water your family use daily, weekly, monthly, and annually, complete one of the following activities:

1. The simplest way to measure water use is to read your family's water meter at the start and end of a 24-hour period. Subtract the first reading you take from the reading made 24 hours later. That's how much water your family uses in one day. Multiply the number of gallons used in one day times seven to find out how much water your family will use in a week. How would you predict your family's water use for a month? A year?

2. If reading the water meter is not possible, measure your family's water use by the following method. The chart provided above will be useful.

    - Keep track of each glass of water used, whether the person drank it or discarded it. Count 6-8 ounces of water per glass.
    - Record the amount of water used to make coffee, tea, juice, or drink mixes. Each quart uses 32 ounces of water
    - Record the amount of water used for cooking, if any. When possible, measure it before use.
    - Keep track of the number of times household toilets are flushed. Each flush uses 3-5 gallons of water.
    - Keep track of water use during baths and showers. Each shower requires about 5 gallons of water per minute. A tub bath uses about 35 gallons of water.
    - Record the amount of water used for washing dishes. Washing dishes by hand requires about 10 gallons of water, while a dishwasher uses about 15 gallons.
    - Record the amount of water used for laundry. Washing clothes on the low cycle uses about 19 gallons of water; the high cycle, 45 gallons.
    - Keep track of any other water uses, such as washing cars or pets or watering the lawn.

3. Now total all the figures and determine your family's water use for a day, a week, a month, and a year. **Amazing, isn't it?**

How do the choices we make, good and bad, affect our water quality?

How can you improve the choices you make concerning your use of our precious water resources?

Put your heads together as a class and brainstorm:

- List ways that water is wasted.
- List ways to conserve water.

Make posters to share your knowledge with others.

[Home] [Up] [Water Cycle] [Water Use] [Water Quality] [Water Pollution]

Water Quality

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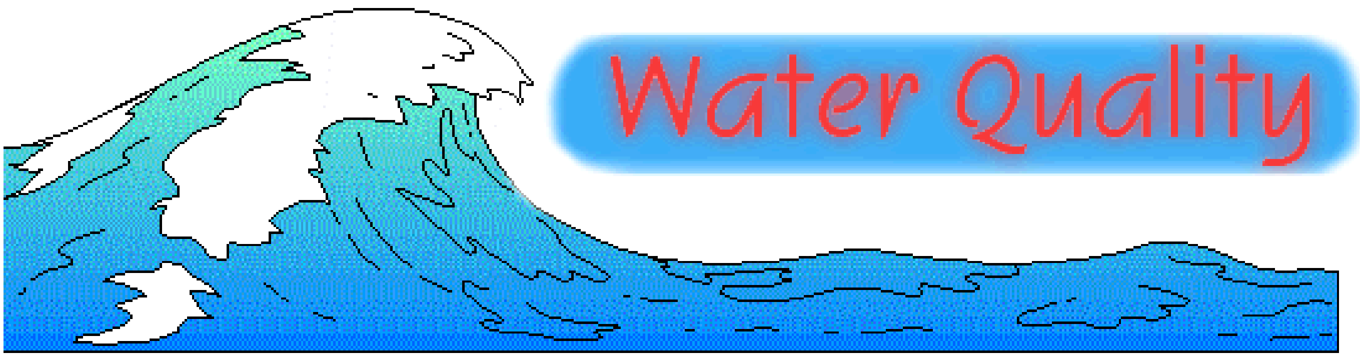
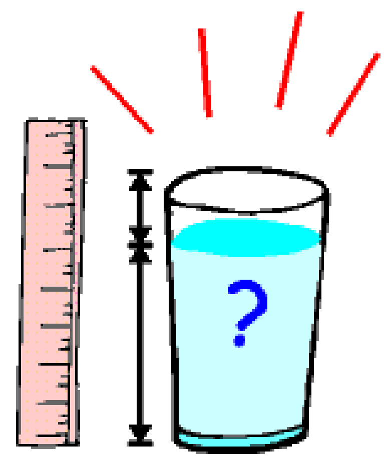


What is polluted water? What is clean water?

WATER QUALITY

How do we measure water quality?



BACKGROUND

In order to protect human health and aquatic life, government agencies set water quality standards that are measured in milligrams per liter (mg/L) - or parts per million (ppm). Some pollutants are measured in parts per thousand (ppt), while others are measured in parts per billion (ppb).

These concepts can be difficult to grasp, so consider such minute amounts of pollutants in more familiar terms:

Unit	LENGTH	TIME	MONEY
1 ppt	1 inch/28 yards	1 sec/17 min	1 cent/$10
1 ppm	1 inch/16 miles	1 minute/2 years	1 cent/$ 10,000
1 ppb	1 in/16,000 mi	1 second/32 years	1 cent/$10,000,000

This is how the water quality measurements are expressed mathematically:

	ppt	ppm	ppb
FRACTION	1/1000	1/1,000,000	1/1,000,000,000
DECIMAL	0.001	0.000001	0.00000001

There are many outstanding activities that you can do to explore water quality. You may even choose to take on water quality issues in the Lake Pontchartrain Basin as an action plan proposed later in this lesson.

Factors that affect water quality generally fall into three major categories: **biological, chemical,** and **physical**. These factors must meet water quality standards set by the state of Louisiana. Here is a chart of the major water quality factors found in the Lake Pontchartrain Basin.

Lake Pontchartrain Basin Water Quality Factors

FACTOR	TYPE	SOURCE(S)	PROBLEM
fecal coliform bacteria	biological	human sewage; livestock wastes	possible presence of pathogenic (disease-causing) organisms
dissolved oxygen (DO)	chemical	air aquatic plants	low levels can kill aquatic organisms
nitrogen and phosphorus	chemical	fertilizers and detergents from lawns and urban runoff	excessive algae growth can lead to low DO and eutrophication
zinc, arsenic, lead, mercury, cadmium, nickel	chemical	saltwater intrusion from the Gulf of Mexico	kills freshwater species of plants and animals
mud, sand, other solid particles (turbidity	physical	erosion and runoff from development, agriculture	reduces photosynthesis in aquatic vegetation; interferes with respiration in aquatic animals

? ?

These are only some of the factors that affect the lake basin's water quality.

- **Which others can you investigate?**
- **Which factors are problems in your area?**
- **Do you ever wonder why you can't swim in Lake Pontchartrain and other bodies of water in the Basin?**

The Basin covers a large area, so there are many natural and human activities that depend on our water resources - cities and towns, farms and ranches, business and industry, and recreation.

ACTIVITY

Using the SOURCES column of the Lake Pontchartrain Basin Water Quality Factors chart above, work with a partner and brainstorm a list of places and things in the Pontchartrain Basin that use water and affect its quality. You might want to refer to a map of the area for some ideas. Compare and contrast your list with the rest of the class.

? ?

- **How did your list match up with those of your classmates?**

As you can see, water use in the Basin is extensive, so water quality is always a concern. If a family of four uses about 300 gallons of water in their home each day, just think of how many additional gallons are needed for growing food and for industrial use.

CONCLUSION

We must wrestle with ways to make the most efficient use of our liquid asset - *water*. We must gain an awareness for conservation of water and develop a willingness to do all we can to conserve it.

Send e- mail to webmasterdeq@LA.GOV or any member of our WWW Task Force
with questions or comments about this web site. To contact us by phone or mail,
see our Office Address/Phone listing.

Water Pollution

Home | Up | What is New? | Events / Notices | Search | About This Site
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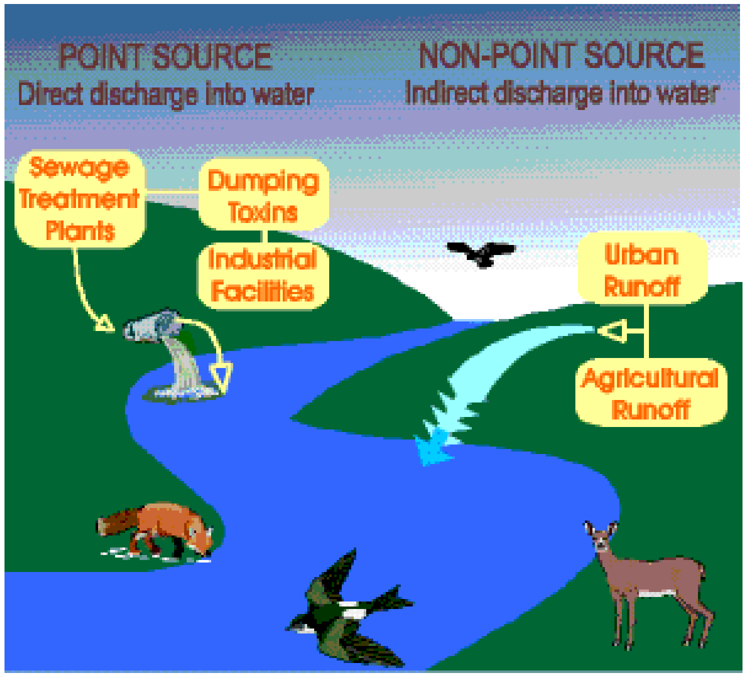
Water Pollution

By now you are probably realizing the truth of these two basic environmental tenets, especially when it comes to water pollution. Simply put, water quality in the Lake Pontchartrain Basin is affected by everything and everybody!

BACKGROUND

Water pollution comes from either a **POINT** or a **NON-POINT SOURCE**.
Let's look at some similarities and differences between the two types.



Point source pollution,

...because it enters the water directly, can be easily traced such as from factories and chemical plants. But non-point source pollution, harder to trace and to treat, can cause long-term damage before the problem is handled. It can come from many different sources and travel long distances through a watershed before it is noticed.

Non-point source pollution,

...provides a greater chance for chemicals to mix and react together. This is known as the synergistic effect. A combination of two or more contaminants can be even more harmful than the original pollutants - and harder to treat.

> **In fact, non-point source pollution is the major cause of water pollution in the Lake Pontchartrain Basin.**

Do you realize that most non-point source pollution comes from runoff?

- *Rainwater or wastewater carries various pollutants along as it flows into our lakes, streams, and rivers.*
- Urban runoff from the south shore of Lake Pontchartrain and agricultural/sewage runoff from the north shore are causing serious water pollution problems in the waterways of the Basin.

Here is a chart to help you understand some of the key non-point sources:

NONPOINT SOURCE POLLUTION CHART: *URBAN RUNOFF*

POLLUTANT	SOURCES	PROBLEMS

sediment	construction; tree removal	increases turbidity; affects aquatic organisms; can contain toxins
phosphates/nitrates	fertilizers; detergents; organic debris	algae blooms; eutrophication
toxins; carcinogens	heavy metals; pesticides; herbicides	disrupt food chain; carcinogenic; cause fish kills
organic debris	animal wastes; raw sewage; grass/leaves	deplete oxygen; disrupt food chain; cause fish kills
petroleum products	motor oil; gasoline; axle grease	disrupt food chain; deplete oxygen; harms birds & mammals
pathogens	animal wastes; raw sewage	health hazards
man-made litter	plastic debris; tires; others	unsightly; harms organisms

?

Some of the same pollutants in urban runoff can also be found in agricultural runoff.

- Which ones are they?
- How do they differ?
- Are there any pollutants unique to agricultural runoff?

ACTIVITIES

A. Complete the following chart:

NONPOINT SOURCE POLLUTION CHART: *AGRICULTURAL RUNOFF*

POLLUTANT	SOURCES	PROBLEMS

After a rain, all these pollutants - urban and agricultural - flow or are pumped into a lake, bayou, or river in the Lake Pontchartrain Basin. While we cannot clean up all forms of non-point source pollution as individuals, it is the responsibility of each of us to do what we can to help stem this toxic tide known as **runoff**.

Project F.U.R. (*Fight Urban Runoff*),

...started by a group of students at Holy Cross School in New Orleans in 1990, has been battling this serious problem. They aim to educate the public about the causes of urban runoff in the basin, so that individuals will be able to take appropriate action. Project F.U.R. is featured in the video, "*Pontchartrain Stories*".

Read more about the award-winning Project F.U.R.

While remarkable strides have been made to reduce water pollution in the Lake Pontchartrain Basin, there is still much work to be done - and it will take the efforts of all of us. Solving the basin's pollution problems will not be easy, but you'll find that there is something you can do.

B. Mini Action Plan

In this next activity, you will design a project of your own. Here are some proposed solutions to current problems. Research one and develop a mini action plan to get you started.

Pollution Problems	Proposed Solution
DUMPING USED MOTOR OIL	*stencil storm drains; recycle used motor; oil & filters*
TRASH AND LITTER	*litter clean-up campaigns*
HABITAT	*plant aquatic grass beds*
DEFORESTATION	*plant cypress trees*
SHORELINE EROSION	*plant trees and other vegetation*

Lake Pontchartrain Basin Pollution Solution

Thinking Ahead

1. Which area of the Lake Pontchartrain Basin do you want to target? e.g., north shore, south shore, coastal marshes
2. Which Lake Pontchartrain Basin pollution problem would you like to help solve?
3. What questions do you have about that pollution problem?
4. Where can you get information about that pollution problem?
5. Which people in your school or community can help you understand the nature of the pollution problem? Which resources are available to you?
6. Which obstacles or potential problems might affect your plan?
7. Brainstorm a list of possible solutions to the problem. Ask others for their ideas about your proposed solutions.
8. Can you do the project alone or will you need volunteer help?
9. Make any necessary changes to your plan.

GETTING DOWN TO WORK

The pollution problem I most want to solve is:

This pollution project is needed because:

My proposed solutions include:

Steps I will take to tackle the pollution problem are:

I will recruit volunteer help from:

I will need to get permission for my project from these people and/or agencies:

The Lake Pontchartrain Basin will benefit from my project because:

The following jobs are to be completed on or before the due date by the person(s) assigned:

JOB CHART

JOB	TARGET DATE	PERSON IN CHARGE

MATERIALS AND SUPPLIES

I will need the following items to complete my project:

FINANCES

If I need to finance my project, I will earn or raise funds by:

PUBLICITY

I will publicize my efforts through:

C. JOURNALING

> **"An environmental journal is one of the best ways to learn issues and keep up with current topics."**
> **- Darren Westfall, student**
>
> **" It helps to write down your point of view to form where you stand on an issue."**
> **- Mixalis Petikas, student**
>
> **"I learned about important topics that should be taught to everyone."**
> **- T. J. Willis, student**

Journal writing is an effective way for students

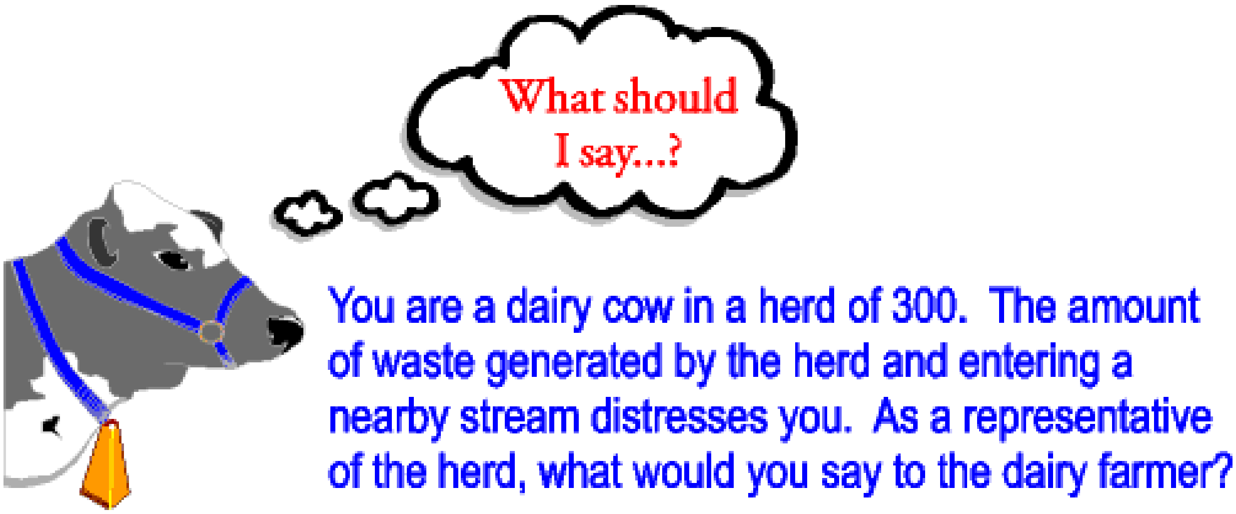
- To reflect on information they are learning.
- To express their thought and feelings on an issue.
- To develop and enhance their writing skills.

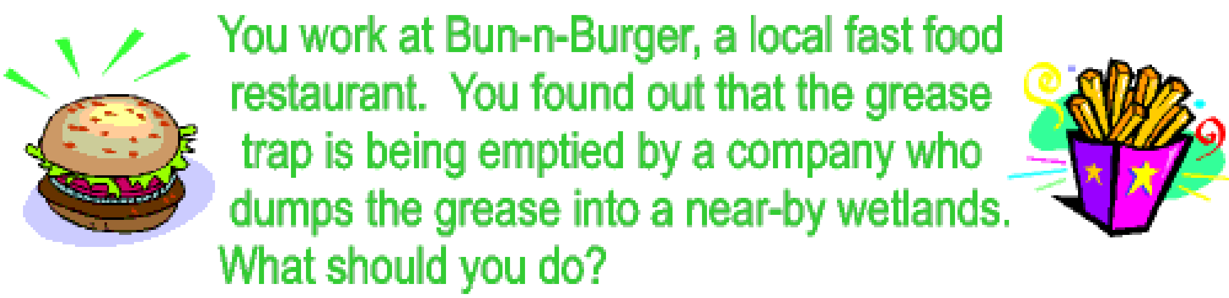
The purpose of this lesson is to offer ways to proceed from personal journal writing to critical journal writing as students examine their present or future place in society.

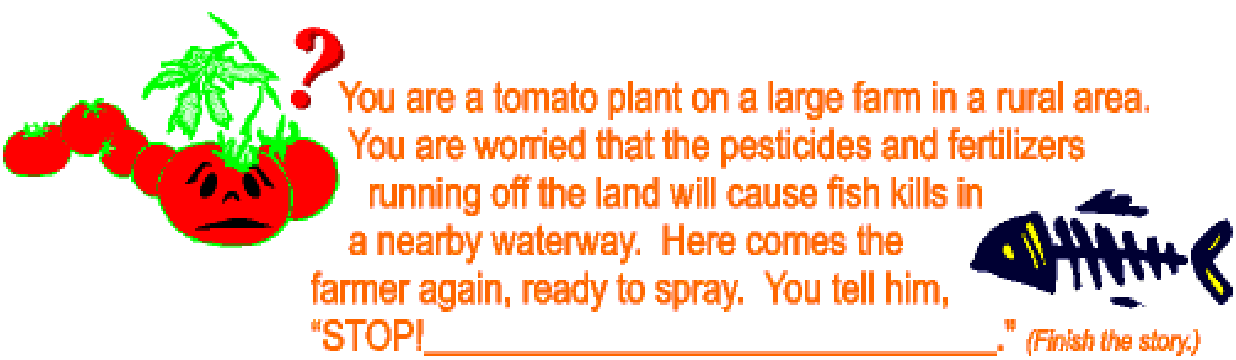
Traditional journal entries encompass questions such as: "What do you know about the topic?" and "What do you think or feel about the topic?" Critical journal writing can require the student to proceed from thoughts or feelings on an issue to formulating a plan of action. An appropriate question to ask would be, "What can you do about the topic?" Students will still be able to write about their feelings and experiences, but their expression will be thoughtful and focused.

Examples of questions for critical journal entries include:

- How do the choices I make, good and bad, affect our water quality?
- How can I improve the choices I make concerning my use of our precious water resources?
- How does my personal use of water affect water quality in the Lake Pontchartrain Basin?
- If I could swim or boat along the shores of waterways in the Lake Pontchartrain Basin, what kinds of pollution would I find?
- How do those pollutants affect living organisms in the Basin?







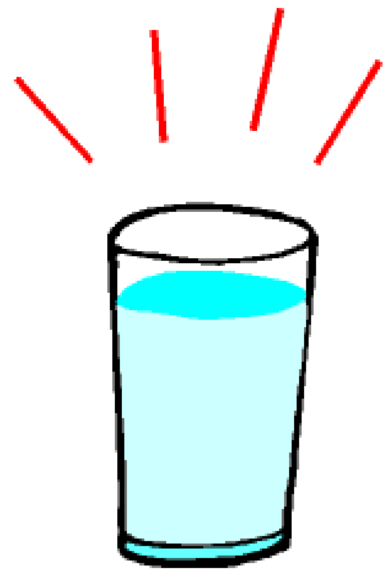
A traditional journal entry, once written, can be a springboard for critical journal writing. Have students take an entry, expand upon it, analyze it, and use it as a basis for a formal essay.

Some strategies for this type of journal entry/essay combination include:

- Developing one's perspective; formulating/exploring beliefs, theories, arguments.
- Assessing consequences of actions.
- Proposing solutions, citing similarities and differences in thoughts or feelings.
- Analyzing actions or examining policies.

This can even by accomplished in small groups, with some students responsible for writing the essay and other students responsible for making a class presentation.

**** Another example of a critical journal entry is to have students listen to or read a* *selected passage, quote, or poem, then react or comment in a journal entry. For example, try this poem on water quality: ****



" The glass of water you're about to drink
Deserves a second thought, I think
For Avogadro, oceans and those you follow
Are all involved in every swallow.
The molecules of water in a single glass
In number, at least five times, outclass
The glasses of water in stream and sea,
Or wherever else that water can be.
The water in you is between and betwixt,
And having traversed is thoroughly mixed.
So someone quenching a future thirst
Could easily drink what you drank first!
The water you are about to taste
No doubt represents a bit of waste
From prehistoric beast or bird
A notion you may find absurd.
The fountain spraying in the park
Could well spout bits of Joan of Arc, or Adam, Eve, and all their kin;
You'd be surprised where your drink has been!
Just think! The water you cannot retain
Will some day hence return as rain,
Or be held as the purest dew.
Though long ago it passed through you!"

- Verne N. Rockcastle

Write a critical journal entry on the poem prompted by such questions as:

1. What do you think or feel about the poetry selection?
2. Why do you feel that way?
3. What is the author trying to tell you about water quality
4. Why do we have a responsibility to not waste or pollute water resources?
5. You are a molecule of water who has spent the last 10,000 years making your way through the water cycle. Trace you family tree. Where does your genealogical search take you?
6. Write the dialogue you have with three other water drops, discussing your travels through space and time.
7. Write an essay based on your responses, or write a poem of your own!

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with questions or comments about this web site.   To contact us by phone or mail,
see our Office Address/Phone listing.

Environmental Rulemaking

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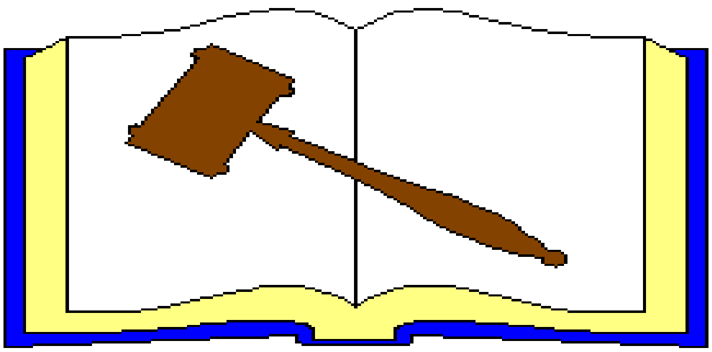
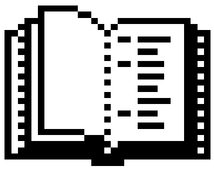


What is Rulemaking?

RULEMAKING - process which allows a proposed regulation to become a rule. This process is outlined by the Administrative Procedure Act (APA).

What State Agency is Responsible for Rulemaking in Louisiana?

LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY (DEQ) - agency concerned with the environmental protection and regulation for Louisiana. DEQ is responsible for the enforcement of rules for the protection of the environment, public health, and safety.



What are the Major Stages in Rulemaking?

1. DEQ submits documents to the Office of State Register for publication in the *Louisiana Register*. The *Louisiana Register* is the official state publication for notifying the public of a proposed regulation. The *Louisiana Register* is published on the 20th of each month.

2. Publication of the following documents in the *Louisiana Register* activates the rulemaking timeclock.

    - Notice of Intent - announces to the public that a change to the DEQ regulations is being considered. It contains a brief description of the rule, the date and time of the public hearing, the deadline to submit comments, and the address for submitting comments.
    - Fiscal and Economic Impact Statement - an estimate of the cost to the State and to those persons affected if the regulation is implemented.
    - Proposed Rule - document which adds new regulations or revises or removes existing text.

3. DEQ conducts a public hearing on the proposed rule 35-40 days after publication of the Notice of Intent. The comment period opens when the Notice of Intent is published and normally closes seven days after the public hearing is held, approximately 42-47 days.

4. After the close of the comment period DEQ prepares the following documents (called the "Summary Report").
    - Summary of the comments received and DEQ's response to them,
    - Concise statement of the comments,
    - List of technical amendments (list of changes made to the regulation since it was proposed, usually as a result of the comments). and
    - Proposed rule with technical amendments incorporated.

    This stage can take as little as a few days or as long as nine months to complete.

5. DEQ submits the Summary Report to the Legislative Oversight Committees. The Legislative Oversight Committees assigned to oversee DEQ regulations are the House Committee on the Environment and the Senate Committee on Environmental Quality.

6. The Legislative Oversight Committees have 30 days to consider the proposed rule. The Committees may, or may not, hold a hearing on the rule. If a hearing is held it must be held between 5-30 days after receipt of the Summary Report from DEQ. If the proposed regulation is identical to an existing federal regulation, this step is shortened to 10 days.

7. If the regulation is not disapproved by the Legislative Oversight Committees, DEQ submits it to the Office of the State Register for publication in the upcoming issue of the *Louisiana Register*.

8. The proposed regulation becomes a final rule upon publication in the *Louisiana Register*.

How Long Does it Take From the Time a Regulation is Proposed Until it Becomes Final?

It varies anywhere from 2 to 12 months. Proposed regulations which are identical to existing federal regulations can become final within 2 months. All other rules take at least 3 months. Rules not finalized within 12 months after publication of the Notice of Intent are void.

[Home] [Up] [Environmental Rulemaking] [Making Smog] [The Smoginator's Air Base] [Lesson Plan: Read My Data] [Radon in your home:] [Recycling Lesson Plan] [Composting Project] [Word Search Puzzle] [Cleanup of Hazardous Waste Sites] [Planning a School Yard Habitat] [Water Fit For A Bug] [Liquid Assets - Our Water Resources] [Build Your Own Aquifer] [Water Filtration] [Make a Water-Cycle Model] [The Water Facts of Life] [Water Waste Bloopers]

Send e- mail to webmasterdeq@LA.GOV or any member of our WWW Task Force with questions or comments about this web site. To contact us by phone or mail, see our Office Address/Phone listing.

Making Smog

This page last updated: 7/16/98

This activity lets students create artificial "smog" in a jar. Teachers can use this module as an introduction to a planned visit from an air-quality scientist, or as the basis for extended discussions on the health problems associated with smog.

CRITICAL OBJECTIVES

- Recognize that invisible air pollutants and weather conditions are involved in creating smog.
- Understand that not all air pollution is visible.
- Appreciate that human activities can cause air pollution.

SKILLS

- Observing
- Drawing conclusions

GUEST PRESENTERS

Guest presenters could include EPA air quality monitoring specialists, state or local air quality managers, chemists, laboratory technicians, or meteorologists.

TARGET GRADE LEVEL

3RD - 5TH

DURATION

20 MINUTES

VOCABULARY

Volatile Organic Compounds	Ozone	Photochemical

Precursor	Smog	Thermal inversion

MATERIALS

- Clean, dry, wide-mouth glass jar (such as a mayonnaise jar)
- Heavy aluminum foil
- Two or three ice cubes
- Ruler
- Scissors
- Stop watch or watch with a second hand
- Matches

BACKGROUND

The expression "smog" was first used in "Turn-of-the-Century" London to describe a combination of "smoke" and "fog". Smog occurred when water vapor in the air condensed on small particles of soot in the air, forming small smog droplets. Thousands of Londoners died of pneumonia-like diseases due to the poisonous air.

Today, smog is usually produced photochemically, when chemical pollutants in the air (notably nitrogen oxides and volatile organic compounds (VOC's) from automobile exhausts) are baked by the sun and react chemically. Ground-level ozone is produced by a combination of pollutants from many sources such as automobile exhausts, smokestacks, and fumes (VOC's) from chemical solvents like paint thinner or pesticides. When these smog-forming pollutants (called "precursors") are released into the air, they undergo chemical transformations and produce smog. Weather conditions, such as the lack of wind or a "thermal inversion", also cause smog to be trapped over a particular area.

Smog causes health problems such as difficulty in breathing, asthma, reduced resistance to lung infections, colds, and eye irritation. The ozone in smog also can damage plants and trees, and the haze reduces visibility. This is particularly noticeable from mountains and other beautiful vistas such as National Parks.

Severe smog and ground-level ozone problems exist in many major cities, including much of California from San Francisco to San Diego, the mid-Atlantic seaboard from Washington, DC to southern Maine, and over most major cities of the South and Midwest.

For more background information, read the "Ozone-Good Up High, Bad Nearby" and "What You Can do to Reduce Ground-Level Ozone fact sheets.

WHAT TO DO

1. Explain that the class will perform and experiment in which they will create artificial "smog" in a jar. Make sure that students understand that the jar is only a model, and models by nature are limited. For example, the purpose of this model is to illustrate the appearance and behavior of smog, not the composition or effects. It is important to understand that smog is not just a "smoky fog", but a specific phenomenon.

2. Select students to perform the experiment. Have them cut a strip of paper about 6 inches by 2 inches. Fold the strip in half and twist it into a rope.

3. Have them make a snug lid for the jar out of a piece of aluminum foil. Shape a small depression in the foil lid to keep the ice cubes from sliding off. Carefully remove the foil and set it aside.

4. Have the students put some water in the jar and swish it around to wet all the inside of the jar. Pour out the extra water.

5. Have them light the paper "rope" with a match and drop it and the match into the damp jar. Put the foil lid back on the jar and seal it tightly. Put ice cubes on the lid to make it cold. (The ice cubes will make the water vapor in the jar condense.) You must do this step very quickly, perhaps with some assistance.

   TAKE NOTE! Be careful to supervise students using matches. DO NOT let anyone breathe the "smog" produced in the experiment, and when the experiment is completed, be sure to release the "smog" outside.

6. Ask students to describe what they see in the jar. How is this like real smog? What conditions in the jar produced "smog"? (Moisture plus soot particles from the burning matches plus carbon dioxide and other solvent vapors.)

7. Ask the students if they have ever seen smog (not fog). Have they ever breathed air outside that smelled funny?

SUGGESTED EXTENSIONS (OPTIONAL)

Have students put a glass thermometer (not plastic) into the jar before they do the experiment. Have them record the temperature before proceeding to step 4. Have them record the temperature during step 5. Ask them to describe what the temperature did and why. Let them try it again without adding water.

SUGGESTED MODIFICATIONS

(a) What conditions are necessary to produce smog in the air? Under what circumstances will these conditions exist in the city? How often are they likely? Can they be predicted in advance?

(b) What are the health effects of smog on people? On plants and trees? Why doesn't everyone in the city get sick or have similar symptoms from smog? What types of people are most sensitive to smog?

For grades 7-12, assign students to small groups to answer the following questions and report back to class in two weeks. One group will consider the physical and chemical sciences and the other group will consider the health and ecological sciences. Each group should consider referring to several sources of information to answer the questions. Students could possibly interview the weather reporter or meteorologist at the local television or radio station or airport, or interviewing a health scientist from the city or county health department or air quality agency.

SUGGESTED READING

Bailey, Donna. *What Can We Do About Noise and Fumes*. New York: Franklin Watts (1991).

Baines, John. *Exploring: Humans and the Environment*. Austin, TX: Steck-Vaughn Company (1993).

Easterbrook, Gregg. "Winning the War on Smog." *Newsweek*, 122 (23 August 1993) p.29.

Krupnick, Alan J., and Paul R. Portney. "Controlling Urban Air Pollution: A Benefit-Cost Assessment." *Science*, 252 (26 April 1991). p.522.

Pasternak, Judy. "Long-Term Lung Damage Linked to Air Pollution; Respiratory Deterioration Is Found in Areas Where Air is Dirtiest." *Los Angeles Times*, (29 March 1991) p. A1.

___. "Smog Blamed for Increase in Asthma Cases." *Los Angeles Times* (2 December 1991) p.A1.

Penny, Malcolm. *Our World: Pollution and Conservation*. Englewood Cliffs, NJ: Silver Burdette Press (1988).

Rock, Maxine. *The Automobile and the Environment*. New York: Chelsea House Publishers (1992).

Scott, Geoff. "Two Faces of Ozone." *Current Health*, 19 (2 September 1992) p.24.

"Study Finds Source of Canyon Haze." *National Parks*, 63 (July 1989) p. 10.

Wald, Matthew L. "Northeast Moving Toward Auto-Emission Goals." *New York Times*, 142 (25 March 1993) p. A12.

The Smoginator's Air Base

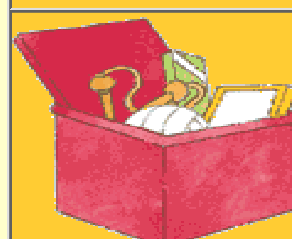
THE SMOGINATOR'S AIR BASE

Meet our new Web Superhero!

Facts and Fun from The Smoginator

Cartoon Series

Kids Art Gallery



Smoginator's Games & Puzzles

Expo Art Winners

The SMOGINATOR........

He's SERIOUS about CLEAN AIR!

Ozone Action Program

Lesson Plan: Read My Data

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This page last updated: 12/31/97

Most environmental decisions and regulations are based upon large quantities of numerical data and trends. This exercise introduces students to the fundamentals of reading and analyzing data and extracting comparisons and averages. It can be delivered by the teacher or a guest presenter, or by both together.

CRITICAL OBJECTIVES

Understand how data is collected and analyzed

Recognize air pollutants the government requires to be monitored

SKILLS

Computing & Analyzing Data

GUEST PRESENTERS

Guest presenters could include environmental protection specialists, air quality engineers, environmental scientists, meteorologists, or others familiar with air quality issues or statistical data.

TARGET GRADE LEVEL

6th - 12th

DURATION

40 minutes (or additional session with guest presenter)

VOCABULARY

Air quality monitoring	Ambient air	Smog	Clean Air Act
Criteria air pollutant	Standards	Attainment	Non-attainment
Photochemical reaction	Trends	Data	Volatile organic compounds

MATERIALS

Paper & Pencils

Background Sheet #1-The Clean Air Act

Background Sheet #2-Smog.

Background Sheet #3-The Criteria Air Pollutants.

Student Worksheet #1.

Student Worksheet #2.

BACKGROUND

No matter where you live, but especially in urban areas, each breath you take contains gases or particles that may be unhealthy. We know this from the analysis of air quality data from around the country. We also know that much of the air pollution is invisible and cannot be detected by human senses. Realistically, in our industrial society, it is not practical to expect that air pollutants can be eliminated totally anywhere, so it becomes important to determine what "acceptable" concentrations will be allowed, and equally important to monitor ambient air quality so that these "acceptable" limits are not exceeded. Most air quality monitoring is done automatically by specialized equipment located strategically throughout the country. These monitoring stations collect vast quantities of data and create a record of the concentrations and durations of specific pollutants. For a list of Louisiana monitoring sites and site documentation, visit DEQ's Air Monitoring Operations.

The Clean Air Act establishes certain "standards," or acceptable levels, for various "criteria" pollutants. Most laws and regulations have separate standards for averaged concentrations over certain short- and long- terms (such as maximum 8-hour average concentrations). The Clean Air Act establishes National Ambient Air Quality Standards for six criteria pollutants: carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, particulate matter (PM-10), and lead. The short-term National Ambient Air Quality Standards (NAAQS) for several of the criteria pollutants are shown in the top line of the two tables in Worksheet 1.

To prepare for the exercises, read the three Background Sheets ***#1-The Clean Air Act***, ***#2-Smog***, and ***#3-The Criteria Air Pollutants***

These exercises look at national air quality trends during the past ten years. They also look at concentrations for the first four "criteria" pollutants in several cities around the country, including New Orleans and Baton Rouge.

Just how clean is your air? You could guess--
but check the accompanying data and find out.

WHAT TO DO

1. Write "1 ppm" on the chalkboard, and next to it write the fraction: 1/1,000,000
   Explain that "ppm" means parts per million" and is similar to "percent" in that "percent" means "parts per hundred." Explain that, like "percent," ppm has no units or dimensions (such as grams or cubic meters). Challenge the class to state which quantity is smaller, 1 ppm or 1 percent. For older students, ask them to compute how much smaller 1 ppm is than 1 percent. Point out that since there are 10,000 "hundreds" in a million, 1 ppm must be 10,000 times smaller than 1 percent.

2. Using ***Student Worksheet 1***, explain to the class what the numbers represent and ask the students to answer the questions. (For more advanced students, request the answers in quantitative terms.) In each table, point out the first line containing the National Air Quality Standards.

3. Using ***Student Worksheet 2***, direct the students to answer the questions and to calculate the percentage change in pollutant concentrations from 1986 to 1995 for the listed pollutants. Call students' attention to the fact that two of the six pollutants have units of µg/m3 which means micrograms per cubic meter, while the other four pollutants have units of ppm, or parts per million. Explain to them that both represent concentrations of pollutants in the air. The four ppm pollutants are all gases, and most fluids (gases and liquids) normally have concentrations expressed as milliliters per liters (part per thousand) or microliters per liter (parts per million). Lead and particulates are solids, and their density cannot be arbitrarily established in relation to air. Therefore, their concentrations are normally expressed as a unit weight (mass) per volume of air. The difference in the units of measure does not affect the calculation of percentage change.

4. Ask the students to identify the most significant changes. Have them speculate as to why the changes might have occurred. Discuss their answers with the guest speaker.

5. Point out to the students that the standards are very different from each other. Ozone's permissible level, for instance, is 75 times lower than that of carbon monoxide. Ask the class to speculate why the standards may be different for different substances. Explain that the human health tolerances are different for each pollutant and each pollutant may cause different health effects. The regulations account for these differences.

SUGGESTED MODIFICATIONS

You can conduct a similar air quality analysis for the area in which your school is located. For more information on Louisiana ambient air quality data, call (225)765-0219 or email your request to deqassistance@LA.GOV. Other states may call the closest EPA Regional Office for information about similar "local" air quality data. To obtain the phone number of the closest EPA Regional Office, visit EPA on the Internet at http://www.epa.gov).

SUGGESTED READING

Baines, John. Conserving Our World, Conserving the Atmosphere. Austin, TX: Steck-Vaughn Company (1990).

Gay, Kathlyn. Acid Rain. New York: Franklin Watts (1983).

Pollution (Science Kit). Delta Education (1990).

U.S. EPA. National Air Quality and Emission Trends Report 1995. October 1996. (Obtain from EPA's Web Site.)

Radon in your home:

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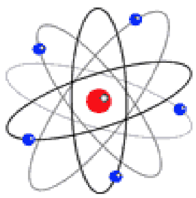

RADON IN YOUR HOME: WHAT YOU SHOULD KNOW

Last updated: 20-Oct-97

WHAT IS RADON?

Radon is a radioactive gas which comes from the decay of naturally-occurring uranium in soil, rock and water and can get into the air you breathe. You can't see radon. You can't smell it or taste it either. But it could be a problem if it gets into your home. In fact, the Surgeon General has warned that radon is the second leading cause of lung cancer in the United States today. Only smoking causes more lung cancer deaths.

WHERE CAN RADON BE FOUND?

Radon can be found all over the United States. It can get into any type of buildings - homes, offices, and schools - and build up to unsafe levels. But you and your family are most likely to get your greatest exposure at home. That's where you spend most of your time.

WHEN DOES RADON BECOME A HEALTH HAZARD TO MY FAMILY?

Your family's risk of developing lung cancer from radon depends on the average annual level of radon in your home and the amount of time you spend there. The longer your exposure to radon, the greater the risk, and the risk is much greater for smokers. The amount of radon in the air is measured in "picocuries of radon per liter of air," or "pCi/l." EPA recommends that you should fix your home if the results of one *long-term test* or the average of two *short-term tests,* taken in the lowest lived-in level of the home, show radon levels of 4 pCi/lor higher. A short-term test remains in your home for two days to 90 days, whereas a long-term test remains in your home for more than 90 days. With today's technology, radon levels in most homes **can** be reduced to 2 pCi/l or below.

WHAT IS THE RISK OF LIVING WITH RADON IN OUR HOME?

Radon gas decays into radioactive particles that can get trapped in your lungs as you breathe. As they break down further, these particles release small bursts of energy. This can damage lung tissue and lead to lung cancer over the course of your lifetime. Not everyone exposed to elevated levels of radon will develop lung cancer, and the length of time between exposure and the onset of the disease may be many years. Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risks. However, we know more about radon risks than risks from most other cancer-causing substances. This is because estimates of radon risks are based on studies of lung cancer in humans (underground miners). Smoking, combined with radon, is an especially serious health risk. Your chances of getting lung cancer from radon depend mostly on: 1) how much radon is in your home; 2) the amount of time you spend in your home; and 3) whether you are a smoker or have ever smoked.

WHO CAN I CONTACT FOR MORE INFORMATION ON RADON?

You can get additional information on radon from the following sources:

- For information, call the Louisiana DEQ Radon Coordinator TOLL-FREE at 1-800-256-2494. The Coordinator distributes a number of EPA publications on radon free-of-charge.

- For free Radon Ranger comic books (A Children's Guide to Radon), call 1-800-256-2494.

- Also visit EPA's Radon Page on the Web at: http://www.epa.gov/radon/

WASTE - WHERE DOES IT COME FROM? WHERE DOES IT GO?

K-12

OBJECTIVES: The students will identify the various waste materials generated in the school. They will describe the sequence of collection and the destination of the materials identified.

RESOURCES: Classroom wastebasket, maintenance personnel, area road map, chalkboard.

PROCEDURE:

1. Separate the class into three groups.

2. Have group one examine the contents of the classroom wastebasket. Ask the group to identify the various types of waste materials generated in the classroom. Categorize the waste materials as paper products, glass, metals, plastics, organic wastes, etc. Record the findings on the chalkboard.

3. The second group should examine the flow of the waste materials after they are collected from the classroom. This may require an interview with maintenance personnel. Are the wastes consolidated with other classroom's wastes? Why? Are the wastes transferred to a large capacity receptacle? Are any wastes burned in a school incinerator? Are any waste materials recycled? If wastes are collected from the school by the municipality or a commercial disposal firm, where are the wastes disposed?

4. Have the third group determine the types of wastes generated in special subject areas of the school (arts and crafts, gym, home economics, industrial arts, etc.), the school cafeteria, the office, the maintenance area. Are these wastes handled in the same manner as classroom wastes? Determine what other wastes are generated by the school. Where do these wastes go?

5. Regroup the class. Have a member or members of each group report the group findings, beginning with group one. Create a diagram or a flowchart on the chalkboard to outline the reports of groups two and three, indicating the steps between waste generation and waste disposal.

6. Ask whether any members of the class live near or have visited a landfill, an incinerator, a recycling center, or a sewage treatment plant. Ask for descriptions and impressions of the facilities. Determine whether any of these facilities are located near the school. You may need to contact your county planning department for the locations. Plot the facility locations and the school location on the road map. Calculate the distances that waste materials must be

transported to each facility. List the type of wastes generated by the school which are managed by each facility and the distance of each facility from the school.

7. (Optional) Arrange a class field trip to one or more waste management facility. Create a class record for each facility. Include photos, drawings, essays, and audio or video tape recordings.

This lesson plan was prepared by the Recycling Division of the Pennsylvania Department of Environmental Protection.

COMPOSTING PROJECT

6-12

OBJECTIVE:
Creating a compost pile as a classroom project will demonstrate to students that natural materials can be recycled.

RESOURCES:
A location for the project, organic waste materials, a garden pitchfork, soil, water. (Lime, manure, nitrogenous fertilizer, materials to construct an enclosure, a ½-inch mesh screen, and a soil thermometer are optional.) Volunteers must be available to construct and maintain the compost pile.

INTRODUCTION:
Compost is an inexpensive and effective soil conditioner that recycles organic waste materials. Nutrients in plant material are returned to the soil through the breakdown of organic material by the action of microscopic fungi and aerobic bacteria. Organic wastes are decomposed, and the result is a material useful as a natural fertilizer.

In Japan, Europe, and recently in the United States, municipalities have established large-scale solid municipal composting facilities. The volume of organic material composted is diverted from other disposal facilities. Municipalities have found that composting leaves collected in the fall can save disposal fees.

When properly managed, a compost pile will not produce odors or attract pests. The finished product can be ready for use as a garden mulch in as little as six weeks with proper management. Compost has proven valuable for use in land reclamation efforts where erosion or earth moving activities have disturbed the topsoil.

PROCEDURE:

1. Find a suitable outdoor site to locate the compost pile. The pile should be exposed to rainfall, but may work best in a shaded location. Proximity to a water source is suggested.

A good time to start a compost pile is whenever organic materials are available. The fall of the year is quite suitable, since composting can serve as an alternative to the burning or landfilling of leaves. Tree-trimmings, grass clippings, garden refuse, kitchen and lunchroom food wastes, sawdust, manure, wood ashes, hay and straw are among the organic wastes suitable for composting. Meat and dairy products should be avoided.

2. Develop a plan of operation that outlines the procedures for conducting the composting

project. Present the plan to the school principal. Permission and support from administrative and maintenance personnel must be obtained before initiation of the composting project.

3. An easy to manage compost pile can be enclosed on three sides by utilizing wooden pallets, used concrete block, fencing, snow-fencing, or hay bales. The fourth side should be accessible to permit turning the pile. A 4'x4'x4' enclosure can yield a ton of compost.

A compost pile can be constructed without an enclosure. A shallow pit may be excavated and the organic material simply piled. The excavated soil will be added to the pile.

4. Begin the compost pile with a layer of branches or cornstalks to help promote ventilation and drainage. The compost pile is then built with successive eight-inch layers consisting of a six-inch layer of organic material moistened with water and covered with two inches of soil, lime, manure or nitrogenous fertilizer. Shredding the organic materials will accelerate the decomposition process.

The eight-inch layers are repeated until the pile is four feet high. Each layer should be moistened, but not soaked. Materials in the compost pile should always remain as damp as a squeezed sponge. A depression created at the top center of the pile will collect precipitation. (Layering of materials is not essential to the process.)

5. The compost pile is now ready for decomposition. During this phase the temperature within the pile may reach 175º F. The heat is effective in eliminating most disease organisms, insects, and weed seeds. Diseased or infested materials should not be added to the compost pile.

The pile should be turned over and mixed every few weeks to move outer materials to the center. Less frequent turning will delay decomposition. A steady decrease in the temperature at the center of the pile will signal the end of the fermentation process. When the compost is finished, it will have a dark color and a crumbly soil-like texture.

6. Maintain a record of the composting process. Enter the date of compost pile construction, the organic materials added to the pile, the days the compost pile is turned, the date the compost is ready, how the compost is used and other observations.

7. A soil thermometer can be used to monitor the temperature of the pile. Create a compost pile temperature chart plotting thermometer readings over the term of the project.

8. The finished compost may be sifted through a ½" mesh screen with rejected particles returned to the compost pile, or the compost may be added directly to garden soil. Applied as a mulch or top dressing around plants shrubs and trees, the compost will provide soil nutrients, retain moisture, and inhibit weed growth. Look for uses for compost around the school grounds. Consider marketing sifted compost as a fund-raising activity.

9. Prepare a report that will describe the composting project. Refer to the project log (Item 6) for key information. Present the report to the school principal. Consider publicizing the project in the school and community newspaper.

This lesson plan was prepared by the Recycling Division of the Pennsylvania Department of Environmental Protection.

Word Search Puzzle

C	O	N	T	A	I	N	E	R	B
H	R	B	V	J	N	D	M	Q	E
E	A	E	F	O	O	D	A	D	D
R	U	R	D	P	H	G	R	A	D
M	F	U	V	W	W	H	X	R	I
U	Q	R	P	E	O	Q	U	K	N
P	U	E	U	M	S	R	G	C	G
M	N	C	O	I	S	T	M	F	O
Q	J	J	G	E	T	L	M	S	R
W	R	I	G	G	L	E	R	S	V

REDWORMS	WRIGGLERS	BEDDING
CONTAINER	FOOD	FRUIT
VEGETABLES	EGGSHELLS	HARVEST
CASTINGS	STARCHES	DARK
	MOISTURE	

Cleanup of Hazardous Waste Sites

PROBLEM FOCUS:

The cleanup of inactive and abandoned hazardous waste sites and placement of such sites on the Superfund, or National Priorities List (NPL).

OBJECTIVE:

To gain an understanding of how a site is cleaned up and how it is placed on the Superfund list (NPL).

BACKGROUND:

Getting a site placed on the NPL and choosing the appropriate method of site cleanup can be a lengthy process. The basic steps used by the Louisiana Department of Environmental Quality (DEQ) to determine cleanup and to determine whether a site will be placed on the Superfund list are as follows:

- **Site Discovery** - Sites are reported by companies, concerned citizens, disgruntled employees, etc.
- **Preliminary Survey** - Consists of a survey taken by driving through an area. The field investigator will investigate the site to see if the reports are true.
- **Preliminary Assessment** - Consists of a collection and review of all reported historical information pertinent to a given site, includes sources and types of hazardous substances present and identifies the potentially responsible parties.
- **Site Inspection** - An on-site investigation is done at this point in the procedure. A typical on-site investigation involves sampling, surveying, monitoring, reconnaissance, and other field activities.
- **Ranking** - A score of 28.5 or greater on the EPA Hazard Ranking System is required to designate the site on the National Priority List Site for funding by the EPA Superfund. The score of a site is based on three conditions: (1) air; (2) ground water, and (3) surface water. Ranking of a site occurs after each site inspection. If a site does not make the EPA minimum point cut-off for the list, the state must do something in terms of cleanup. If a site is deemed an emergency situation, it is taken out of the point program and remedial action (cleanup) is undertaken. Direct contact by a population and potential for fire and explosions are used as determining factors in the desirability of an emergency removal action.

- **Site Inspection Follow-up** - An on-going investigation of EPA and DEQ personnel of unanswered concerns and questions about the site is completed. Suggestions are made to clean up the site and the cost of further action is assessed.
- **Expanded Site Inspection** - The additional investigation of concerns and questions about the site is completed here. It serves as a reinforcement for step 6.
- **Expanded Site Inspection Follow-up** - Reinforces the investigations with closer supervision by EPA and DEQ personnel.
- **Remedial Investigations** - The following items are completed during this phase of the investigation: (1) visitation to the site; (2) definition of boundaries of contamination and (3) determination of extent and degree of contamination of each of the conditions - air, soil, surface water, etc.

State and federal governments must agree on cleanup procedure and on a schedule for the cleanup.

The following are several ways to finance the cleanup of a Superfund site: (1) responsible party can clean up the site voluntarily; (2) through federal assistance using Superfund money and using a contractor for cleanup; (3) responsible party can be forced to cleanup through legal action and (4) state and local governments can assume the cost of cleanup and use a contractor for cleanup.

Remediation Services, a division the Louisiana Department of Environmental Quality's Office of Environmental Assessment, has the task of administering the state hazardous waste cleanup fund and projects funded through the U.S. EPA's Superfund program. To that end the Remediation Services Division ranks potentially hazardous waste sites to be included on the National Priority List maintained by the EPA for cleanup action. The method used to rank these sites is to score them as to their possible impact on public health and welfare, using criteria such as the contamination of ground water, surface water and air in the vicinity of an inactive or abandoned hazardous waste site. The Remediation Services Division develops supporting information for each site, including monitoring well data, census population figures and surveys of drinking water wells. Louisiana has approximately 400 sites that are being evaluated as potentially hazardous inactive waste sites.

METHODS OF HAZARDOUS WASTE SITE CLEANUP - EXAMPLES & ILLUSTRATIONS

HAZARDOUS WASTE SITE CLEANUP - CASE STUDIES

All pages herein best if read using MS Internet Explorer or Netscape version 6 or greater.

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Planning a School Yard Habitat for St. Thomas More School

St. Thomas More Schoolyard
Site of Planned Habitat Project

Personnel with the Louisiana Department of Environmental Quality are currently helping in the design and construction of the St. Thomas More Schoolyard Habitat in Baton Rouge. The habitat's initial feature will be a pond and stream landscaped with native Louisiana aquatic plants. Using the pond, students and teachers will learn about aquatic habitats and food chains, native plants and stream hydrology.

Teachers and personnel from DEQ will develop lessons, in order to ensure they meet the needs of the students. By presenting these topics in an interactive, hands on way, students will gain a greater appreciation of the natural resources they will be charged with protecting as they grow older. They will also learn first hand the types of work done by biologists, hydrologists, and environmental scientists.

Following completion of the pond, the remainder of the habitat will be developed using native herbaceous plants, shrubs and trees. This phase will be largely developed by the students and teachers themselves as they learn about the requirements of animals in our area, and the specific needs of the plants. By placing the right plant species in their correct environment, long term survival of the plants should be improved. This will reduce both maintenance and costs.

Through the interaction of students, teachers and environmental professionals the St. Thomas More Schoolyard Habitat will ensure the development of citizens both knowledgeable about their environment and able to make wise decisions about its conservation.

Pond layout is to begin April 10, 1999 with digging and installation to be completed April 17-18, 1999, weather permitting. More details of the project, and pictures of its construction will be included as the habitat is developed.

Pond Construction (PowerPoint)

Digging and Lining

Planting

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Water Fit For A Bug

A Lesson in Evaluating Water Quality

Macroinvertebrate Sampling for Evaluating Water Quality

Overview

Water "bugs" (macroinvertebrates such as insect larvae, snails, crawfish, sowbugs, clams, aquatic worms and leeches) are excellent indicators of water quality, as they live much of their life cycle in the same area of a stream or lake. This lesson demonstrates how to collect stream debris samples, locate, identify and sort "bugs" within the samples, and evaluate water quality based on species diversity and population. Students of all ages can also gain some understanding of the basic causes and significance of water quality problems, as well as potential solutions.

Lesson Description	
Age	can be adapted to any age depending on level of concepts presented and detail of analysis desired
Subjects	biology, zoology, entomology, ecology, and math

Skills	analysis, classification, observation, computation, and dexterity and confidence in the use of equipment (dip nets, magnifying boxes, magnifying glasses, etc.)
Duration	A minimum of 45 minutes should be allowed, if samples are brought to classroom. (Pre-collection time by instructor is dependent on location of suitable water body), 1.5 - 2 hours is best if students are to observe or participate in the sample collection and then sort the samples. Patience and interest is an important factor in the length of time that students actually sort samples.
Group size	A class of 20-30 students may be divided into groups of about 5 students per sample pan. More can be accommodated, if additional instructors are available to help the leader.
Setting	The lesson may be conducted outdoors near a wadeable stream or lake. If collected stream debris is brought to the school or classroom, the lesson should be conducted in an area where spilled water and mud are not a problem.
Key Vocabulary & Concepts	macroinvertebrates, insects, water pollution, pesticides, environment, ecology, life cycles, habitat, experimental method

Accompanying "Bug Sheet"

Objectives

- collect stream debris samples from suitable habitats (or have the sample brought to them)
- locate and identify macroinvertebrates in the samples
- evaluate water quality based on species diversity and population

- understand basic causes and significance of water quality problems along with potential solutions

Method

Ideally, students will be taken to a suitable (safe and wadeable) stream or lake where collection techniques will be demonstrated. If possible, students will be able to collect samples on their own in order to better learn collection techniques. If students cannot go to a water body, instructor can go before the demonstration and collect a large enough sample to divide evenly between groups. After sample collection is complete, students will pick through the debris to locate and then identify macroinvertebrates that can be used to estimate water quality.

Background

Macroinvertebrates are a large group of organisms whose common element is that they lack a backbone. They range from such varied creatures as jellyfish, octopus, worms and leeches, to oysters, clams and snails, to crabs, crawfish and insects. They can be as large as giant squid in the ocean which reach several feet in length or smaller than a flea. Fortunately, what this experiment is looking for falls somewhere in between.

Aquatic macroinvertebrates include primarily larval forms of both common and uncommon insects. Commonly seen insect larvae include dragon flies and damselflies. Less common insects include stoneflies, mayflies, alderflies, midge fly and blackfly larvae. Non-insect indicators include snails, crawfish, sowbugs, clams, aquatic worms and leeches. These and a variety of other macroinvertebrates can be identified using an easy to read "Bug Sheet" which gives generalized body patterns for each of the indicator organisms along with brief characteristics. The sheet also shows which water quality group each indicator organism falls in. Water quality groups include: 1) pollution sensitive ("good water bugs"); 2) somewhat pollution tolerant ("moderate water bugs"); and 3) pollution tolerant ("bad water bugs").

Macroinvertebrates living in any body of water provide excellent indicators of water quality because they are generally forced to live out much if not all of their life cycle in the same area of a stream or lake. Many otherwise terrestrial insects such as stoneflies, dragon flies and midge flies pass through an aquatic larval stage during which they develop into winged adults then fly away to mate and lay eggs, thereby completing their life cycle. In most cases, especially with the mayflies, the largest part of their life span is spent as larvae living in the water. Mayflies take this to such an extreme that the adults generally do not have mouth parts and die within a day or two of emerging and mating, hence their taxonomic name of Ephemoptera.

Other macroinvertebrates live their entire lives in the water. Aquatic snails, crawfish, sowbugs, clams and leeches are all dependent on water for their entire life. However, among these creatures there is still a variety of tolerances to pollution. Gilled snails are dependent on good water quality because they must obtain all of their oxygen from the water. Pouch snails on the other hand can tolerate poor water quality with little oxygen because they are capable of leaving the water and obtaining oxygen from the air. These two types of snails can be separated by the side on which their shells open when the pointed tip is away from the viewer; right for good water snails, left for poor water snails. They can also be separated by the presence of an operculum or "door" on their shell opening. Pouch snails lack an operculum.

Crawfish, sowbugs and clams are all macroinvertebrates generally found in water of at least moderate quality. Crawfish are well known in Louisiana as a delicious meal. Sowbugs are related to common wood lice, otherwise known as "pillbugs" and "roly-polys." Clams are generally small, easy to locate creatures which are obviously dependent on water. Finally, aquatic worms and leeches are both indicators of poor water quality; and no the leeches will not suck your blood, unless you give them a good chance.

Because these organisms depend to varying degrees on clean water, it is possible to evaluate a water body's health based on the type and number found through sampling. However, because each type of macroinvertebrate has a different lifestyle it is important that samples be collected systematically from all suitable habitats so that each habitat type is evenly represented. For example, if collections are only made along steep banks you may find a few mayflies, stoneflies and crawfish, while a much larger population of midge fly and blackfly larvae are living on rocks in the middle of the stream. This could result in an evaluation of good water quality, when in fact the water is of moderate or even poor quality. The important point to remember is that just because you have one good water indicator you do not necessarily have good water. Likewise, having a few poor water indicators does not always mean you have poor water. Ideally, there should be a range of organisms, with a higher percentage of good or moderate water quality species. An evaluation form is utilized to help in this determination.

Water quality can be impaired by a variety of causes and sources. High levels of nutrients from sewage or fertilizers can lead to algae blooms which block sunlight preventing normal aquatic vegetation growth. Reductions in normal vegetation can lead to reduced hiding places for macroinvertebrates and fish, thereby reducing their populations. When this excess algae dies, decay processes caused primarily by bacteria can severely reduce the amount of oxygen in a stream or lake leading to fish kills and reductions in populations of macroinvertebrates sensitive to oxygen levels.

Another source of water quality impairment, one that many people don't think about, is removal of stream bank vegetation. When landowners or flood control managers strip away riparian vegetation from a stream or lake many things happen to the water body. Removal of sheltering limbs and tree roots which provide hiding places for macroinvertebrates, fish, turtles, frogs, snakes, birds and a host of other wildlife frequently leads to loss of these creatures. Removal of streamside vegetation causes water temperatures to rise due to increased sunlight. Rising temperatures reduce the amount of oxygen in the water, cause fish to move away and may promote more algae blooms. Loss of vegetative structure on a stream bank will lead to increased erosion which places more sediment in the stream. Excess sediment can harm fish and other creatures, smother eggs, block sunlight from aquatic vegetation, and actually increase flooding as sediment is redeposited and fills up basins which normally hold back excess water. Finally, removal of riparian vegetation allows pollutants which might otherwise be trapped and degraded by the plants to enter a stream where they can kill fish and other stream life.

Improper use of pesticides around homes, businesses and farms is one form of water quality impairment which may be harder to detect because you cannot readily see the impact. However, macroinvertebrates, fish and other wildlife living in or around a water body will feel it. Pesticides by definition kill pests, whether insect pests or weeds. Unfortunately, many pesticides are extremely toxic to birds, fish and macroinvertebrates, so when used improperly they can enter a water body and kill much of the life found there. This is where macroinvertebrate sampling can really come in handy. A stream or lake may look almost pristine if the water is clear with little or no vegetation and algae, but if pesticides have been periodically introduced it is possible that sensitive indicators like mayflies, stoneflies and caddisflies have been killed off. Proper sampling will detect this and alert investigators to look for sources of the problem.

There are many examples of water quality impairment which macroinvertebrate sampling can help detect. Perhaps the most important aspect, however, is becoming familiar with a water body's habitats, ecology and watershed. By doing so, students can take action toward protecting the overall environment of a water body, thereby protecting much more than just the water.

Materials

1. sturdy D-frame aquatic sampling net - at least one for instructor (available from Carolina Biological Supply, 1-800-334-5551 or Forestry Suppliers, Inc., 1-800 647-5368)

2. for every five students need one of each item listed - plastic dishpan approximately 12" x 14" x 5" for sorting samples, forceps (preferably soft tip entomology forceps but ordinary ones will work (available from Bioquip, 310-324-0620)), medicine dropper and or kitchen baster, two ice cube trays, and in order of preference - a plastic two-way microscope (available at Nature Company Store in New Orleans) or Discovery Scope (available from Delta Education, 1-800 442-5444) or hand lens magnifier

3. 1 bug sheet, 2 sample recording sheets and a pencil for each student

4. large washtub or buckets, if sample must be collected in advance and brought to classroom

5. waders, if desired, for any one planning to wade in the stream

Procedures

1. Overall concept of project based on Background, above, is presented to students in classroom or stream side. Emphasis can be placed on experimental nature of project because leader usually does not know what the results will be. Even if sampling has been previously done on the same stream conditions could have

changed between tests. Basic environmental aspects can be presented now or held until after sampling and analysis is complete.

2. Sampling procedure with net is demonstrated either in the water or on land as appropriate. Different habitat types should be pointed out and described, including:
   - vegetated margins and banks
   - silty substrates with organic debris
   - sandy/gravel bottoms
   - woody debris with associated leaves, algae and fungi

3. If possible, each habitat type should be sampled according to the following procedures. In each case, be sure to look at the inside of the net after dumping a sample into the dishpan. Many of the invertebrates can be found clinging to the netting.

Vegetated margins and banks should be vigorously scooped from the bottom up, starting 2-3 feet down and finishing at the surface. Sand, silt, mud and vegetation should be retained in the net with water allowed to drain away. This should be done for approximately 10 feet of stream bank, working upstream. Retain this sample in one pan or divide among several if needed. Record or remember what type of sample is in each pan. This area will usually have a good diversity of several macroinvertebrate types particularly mayflies, stoneflies, dragon flies, and damselflies. In slow streams, lakes and ponds vegetation may be the best location to find suitable habitat and macroinvertebrates, especially dragon flies and damselflies, but also scuds and sowbugs. If you want to find something quick and easy try here first.

Woody debris should be collected from any area of the water body where it can be found. Debris piles should be approached from downstream with the sampling net held below and downstream while leaves and other loose items are pulled into the net. Small pieces of wood approximately 3 inches in diameter should be collected until you have a total of 4 or 5 feet of wood. Retain samples in one or more pans and remember sample type. Like stream banks, woody debris is usually a good place to sample, especially in slow streams. Look for mayflies, stoneflies and beetle larvae, but large dragonflies can be prowling for other insects and caddisflies can be found filtering the water with tiny nets. Again, like stream banks, this is a good source for quick and easy sampling.

Sandy/gravel bottoms in still water can be sampled by vigorously scooping substrate from the bottom. Move the net approximately three feet across the bottom trying to dig in 1-2 inches. In moving water, scoop as before working upstream so organisms are swept into the net or position the net downstream of a 3-foot sampling area and kick around in the sand and gravel to disturb the substrate and force organisms up into the current. Retain sample as before. This area is not as productive as the previous two locations, but you can find midges, clams, swimming mayflies and very interesting case-building caddisflies.

Silty substrates are found where current is very slow or absent. Samples can be collected as described under sandy/gravel bottoms. This is usually the least productive area, but you may find burrowing mayflies if enough oxygen is present. This is an important area to check for the adequacy of oxygen levels in the stream or pond because this will usually be a low oxygen area. If mayflies are found here the oxygen level in the rest of the water body should be very good.

As was noted in the background section, it is important to try and sample all of the habitat types in order to be most accurate. However, if time is a factor and you want to just find something concentrate on the first two habitats above. These two areas will almost always have something to look at. If comparisons are being made between two different water bodies it is very important to sample the same habitat types, with the same intensity, in each water body.

1. After all samples have been collected and divided into dishpans, groups of no more than 5 or 6 should begin picking through the samples. Students should be told that they are looking for creatures anywhere from about 1/8 inch to 2 inches, with an emphasis on the smaller. Scuds and beetle larvae will usually be on the small side, mayflies and stoneflies are usually about 1/4 - 1/2 inch, while dragonflies and damselflies are usually the largest thing found. However, hellgrammites and craneflies can both be very large but are rarely found. To possibly help alleviate fears of putting their hands in the debris, students can be told that hellgrammites are the only thing that may bite and these are usually large and easy to spot. (Hellgrammites have large pincers on their heads and can give a nasty bite.)

Picking should be done by removing small portions of the debris, one or two leaves at a time, and looking it over closely. Forceps or medicine droppers can be used to pick-up smaller organisms. Woody debris should be scanned carefully on the surface and then loose pieces broken away to find mayflies, stoneflies and caddisflies which hide in crevices. When looking at debris remember the idea of camouflage. Most of the organisms will be brown or black and blend in very well with their surroundings. In green vegetation, damselflies will frequently be green and just as hard to see. Without care, you can almost look right at a mayfly on a stick and not see it. Look for movement to give the creatures away. Water should be kept to a minimum in the pans because it is usually murky, however, if the water is clear enough macroinvertebrates can usually be seen swimming around in the bottom. For this reason, any water present in a pan should be kept as calm as possible to avoid stirring up the mud.

As organisms are located they should be separated into look-alike groups by placing them in individual cells of an ice cube tray. The bug sheets will come in handy here. Microscopes or hand lens can be used to help identification or observe behaviors. Ice cube cells should be filled with tap or clear stream water so that the organisms can be seen and counted. For example, all dragon flies should go in one cell, all mayflies in another, etc. The reason for this is two fold: one, dragon flies, damselflies and hellgrammites will eat anything in a cell with them; two, this facilitates counting the organisms according to taxonomic and water quality groupings. And watch some of the creatures, they are surprisingly mobile and may crawl out of their cell or even the tray. When asked, try not to simply tell students what a particular organism is. Instead, try to guide them to find the answer themselves. For most of the larger macroinvertebrates it is really pretty easy. As the invertebrates are located, identified and separated students should keep a tally of how many of each type they find. This can be done individually or by a group recorder.

2. After at least 20-30 minutes of picking bugs students should be told to complete there tally of each organism type and select one person to call-out their results when asked to. A few more minutes is usually required to complete the tallies. Time spent picking bugs can be highly variable depending on the age and interest of the students. To be completely accurate may take an hour or more of picking for each pan, especially those with a lot of debris, but few groups can sustain their interest that long.

3. While students are completing their tallies the instructor should prepare a black board or flip chart, listing each macroinvertebrate in a fashion similar to that found on the survey form. When ready, each group can call out the number of each macroinvertebrate type they found (ie. 10 stoneflies, 5 gilled snails, 20 dragon flies, etc.). The total for all groups is recorded on the black board and on a master survey form. If more than one water body was sampled, results for each water body should be maintained separately. Students should be asked to complete one survey form based on their own samples. If desired, a second survey sheet can be completed by each student showing overall water body results. By maintaining separate group survey forms it should be possible to show results for different habitat types if each group had a different habitat sample.

4. When all results have been tallied the instructor can explain the use of index letters as shown on the survey forms. See analysis below. If time becomes a critical factor, explanation and use of index letters can be left out and raw numbers and distribution among water quality groups can be used to informally estimate water body quality. If time permits, students can discuss possible impacts to water quality in general and the sampled water body in particular.

5. After completion it is important that all participants wash their hands well with soap and water. This is especially important with small children and when samples were collected from areas of questionable sanitary condition.

Analysis

The survey forms explain the use of letter coding to tally both the presence and population of each indicator group found. The number of letters in each water quality group is determined and then multiplied by the appropriate group factor (ie. # of letters x 3 = index value for sensitive indicators, # of letters x 2 = index value for somewhat tolerant indicators, and # of letters x 1 =

index value for tolerant indicators). These values are added together to get a total index value. Values > 22 indicate excellent water, values of 17-22 are good, 11-16 is fair and < 11 indicates poor water quality.

Remember, the important point is not to have all good water species and no bad water species. Instead, a high quality water body will have a wide diversity of all indicator types from sensitive to tolerant, with, hopefully, a larger number of sensitive or moderately tolerant organisms. Also, this survey was originally designed for clear, flowing northern U.S. streams. Although scores and techniques have been modified slightly, it does not always accurately assess Louisiana, and especially South Louisiana waters. Obviously, if you sample a relatively clear, fast moving central Louisiana stream you will have different results than if you sampled a farm pond or bayou. Both water bodies may have perfectly operating environments with no pollution impacts; however, the stream will have many sensitive indicators such as mayflies and probably rank as having excellent quality, while the pond will probably have more moderately tolerant organisms such as dragon flies and give a rank of good or fair. This is primarily due to oxygen levels, water temperature and habitat availability.

Sampling which finds little variety in the type of macroinvertebrates found, but high populations of each may indicate water enriched with organic matter. Locating only one or two types of macroinvertebrates in very high abundance indicates severe organic enrichment. If a good variety of organisms was found but at low numbers then toxic pollution may be indicated; however, other problems could also cause reduced populations. This program works best when the same or very similar water bodies can be sampled over time so that results can be compared. However, since use of the sampling program for demonstration purposes generally precludes that possibility, it is up to the instructor to gain as much familiarity as possible with what can be expected of different water bodies. This will allow reasonable comparisons and interpretation of what is found in the demonstration water body.

Extensions

This program lends itself to a number of possible extensions and discussions. Aspects of water pollution can be discussed in association with what pollution does to the life of a water body. Discussions on food webs can begin with vegetation and algae growing in water and continue all the way to fish and humans. The macroinvertebrates found during the program form a lower or middle area of the food web, between vegetation and minnows or larger fish. Within the macroinvertebrates there are good examples of smaller food webs because some of the organisms are grazers or detritivores on the fungus and plants (mayflies and stoneflies); some are filter feeders (caddisflies); and some are carnivores (dragon flies and damselflies). If a relatively good microscope is available, placing a drop of water on the slide and allowing students to look at it on their own will show an entire new layer of the food web in the diatoms, flagellates and other microorganisms present.

The concept of watersheds is an important aspect of water pollution control which can be discussed either before or after the sampling program. A watershed is the land area which acts as a collection basin for rainwater which eventually flows to a single stream or river. Watersheds can be as small as a single valley and creek or as large as the Missouri, Mississippi and Ohio River system and its myriad tributaries. This watershed encompasses 30 states in the continental U.S. stretching from Montana in the west to New York in the east, and all the way north into Canada.

Nonpoint source pollution is another aspect of water pollution which can frequently be identified by macroinvertebrate sampling techniques. Stream sampling, along with field scouting of the watershed can frequently locate water quality problems not readily identified by conventional water quality sampling. The Louisiana Department of Environmental Quality, Office of Environmental Assessment maintains a Nonpoint Source (NPS) Program which can provide more information on this important form of water pollution. The NPS program also works with citizen environmental groups to establish Citizens' Monitoring Programs on area streams. Students who wish to pursue this area can be encouraged to contact the department at (225) 765-0355 for more information.

Accompanying Survey Form

This lesson was prepared by:

Al Hindrichs
Louisiana Dept. of Environmental Quality

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Build Your Own Aquifer

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Safe Drinking Water Lesson:

Build Your Own Aquifer

BACKGROUND:

Many communities obtain their drinking water from underground sources called **aquifers**. Water suppliers or utility officials drill wells through soil and rock into aquifers for the groundwater contained therein to supply the public with drinking water. Home owners who cannot obtain their drinking water from a public water supply, will have their own private wells drilled on their property to tap this supply. Unfortunately, the groundwater can become contaminated by harmful chemicals, including improper disposal of household chemicals such as lawn care products and cleaners and any number of other pollutants. These chemicals can percolate down through the soil and rock and into the aquifer - and eventually the well. Such contamination can pose a significant threat to human health. The measures that must be taken by well owners and operators to either protect or clean up contaminated aquifers is quite costly.

NOTE: This demonstration should follow a class discussion on potential sources of pollution to drinking water supplies.

OBJECTIVE:

To illustrate how water is stored in an aquifer, how groundwater can become contaminated, and how this contamination ends up in the drinking water well. Ultimately, students should get a clear understanding of what happens above the ground can potentially end up in the drinking water below the ground.

MATERIALS NEEDED:

1 6" x 8" clear plastic container that is a least 6-8" deep (shoe box or small aquarium)
1 lb. of modeling clay or floral clay
2 lbs. of white play sand
2 lbs. of aquarium gravel (natural color if possible) or small pebbles
(As any small rocks may have a powdery residue on them, you may wish to rinse them and dry on a clean towel prior to use. It is best if they do not add cloudiness to water.)

1 drinking water straw
1 plastic spray bottle (be sure the stem that extends into the bottle is clear)
1 small piece (3 x 5) of green felt
1/4 cup of powered cocoa
red food coloring
1 bucket of clean water and small cup to dip water from bucket
scotch tape

PROCEDURE:

1. To one side of the container place the small drinking water straw, allowing approximately 1/8 of an inch clearance with the bottom of the container. Fasten the straw directly against to the long side of the container with a piece of tape. Explain to the students that this will represent two separate well functions later in presentation (if not placed at this time, sand will clog the opening).

2. Pour a layer of white sand completely covering the bottom of the clear plastic container, making it approximately 1 " deep. Pour water into the sand, wetting it completely, but there should be no standing water on top of sand. Let students see how the water is absorbed in the sand, but remains around the sand particles as it is stored in the ground and ultimately in the aquifer.

3. Flatten the modeling clay (like a pancake) and cover of the sand with the clay (try to press the clay into the three sides of the container in the area covered). The clay represents a "**confining layer**" that keeps water from passes through it. Pour a small amount of water onto the clay. Let the students see how the water remains on top of the clay, only flowing into the sand below in areas not covered by the clay.

4. Use the aquarium rocks to form the next layer of earth. Place the rocks over the sand and clay, covering the entire container. To one side of your container, slope the rocks, forming a high hill and a valley. Now pour water into your aquifer until the water in the valley is even with your hill. Let students see the water around the rocks that is stored within the aquifer. They will also notice a "**surface"** supply of water (a small lake) has formed. This will give them a view of both the ground and surface water supplies which can be used for drinking water purposes.

5. Next, place the small piece of green felt on top of the hill. If possible, use a little clay to securely fasten it to the sides of the container it reaches.

6. Using the cocoa, sprinkle some on top of the hill, while explaining to students that the cocoa represents improper use of lawn chemicals or fertilizers, etc.

7. Use the food coloring and put a few drops into the straw, explaining to students that often old wells are used to dispose of farm chemicals, trash and used motor oils. They will see that it will color the sand in the bottom of the container. This is one way pollution can spread through out the aquifer over time.

8. Fill the spray bottle with water. Now make it rain on top of the hill and over the cocoa. Quickly students will see the cocoa (fertilizer/pesticide) seep down through the felt and also wash into the surface water supply.

9. Take another look at the well you contaminated. The pollution has probably

spread further. Now remove the top of the spray bottle and insert the stem into the straw, depress the trigger to pull up the water from the well. (Water will be colored and "polluted.") Explain that this is the same water a drinking water well will draw up for them to drink.

EPA Publication # 810/F-95-005, October 1995

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Water Filtration

Safe Drinking Water Lesson: Water Filtration

BACKGROUND:

Water in lakes, rivers, and swamps often contains impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from surface sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: (1) **aeration;** (2) **coagulation;** (3) **sedimentation;** (4) **filtration;** and (5) **disinfection.** Demonstration projects for the first four processes are included below:

OBJECTIVE:

To demonstrate the procedures that municipal water plants use to purify water for drinking.

MATERIALS NEEDED:

5 Liters of "swamp water" (or add 2 cups of dirt or mud to 5 liters of water)
1 Two liter plastic soft drink bottle with its cap (or cork that fits tightly into the neck
2 Two liter plastic soft drink bottles - one bottle with the top removed and one bottle with the bottom removed.
1 One and one half Liter (or larger) beaker or another soft drink bottle bottom
20 grams of alum (potassium aluminum sulfate - approximately 2 tablespoons; available in pharmacy or spice isle in grocery store)
Fine sand (about 800 ml in volume)
Coarse sand (about 800 ml in volume)
Small pebbles (about 400 ml in volume) (Hint: washed natural color aquarium rocks will work)
1 large (500 ml or larger) beaker or jar
1 coffee filter
1 rubber band
1 tablespoon
A clock with a second hand or a stopwatch

PROCEDURE:

1. Pour about 1.5 L of "Swamp Water" into a 2 L Bottle. Have students describe the appearance and smell of the water.

2. **Aeration** is the addition of air to water. It allows gases trapped in the water to escape and adds oxygen to the water. Place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cut-off bottles, then pouring the water back and forth between the cut-off bottles 10 times. Ask students to describe any changes they observe. Pour the aerated water into a bottle with its top cut off.

3. **Coagulation** is the process by which dirt and other suspended solid particles are chemically "stuck together" into floc so that they can be removed from water. With the tablespoon, add 20 g of alum crystals to the swamp water. Slowly stir the mixture for 5 minutes.

4. **Sedimentation** is the process that occurs when gravity pulls the particles of floc (clumps of alum and sediment) to the bottom of the cylinder. Allow the water to stand undisturbed in the cylinder. Ask students to observe the water at 5 minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance.

5. Construct a filter from the bottle with its bottom cut off as follows:

a. Attach the coffee filter to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle - the filter will prevent the pebbles from falling out of the neck.

b. Pour the coarse sand on top of the pebbles.

c. Pour the fine sand on top of the coarse sand.

d. Clean the filter by slowly and carefully pouring through 5 L (or more) of clean tap water. Try not to disturb the top layer of sand as you pour the water.

6. **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment have settled on the bottom of the bottle of swamp water, carefully - without disturbing the sediment - pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water back into the collection container. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.

NOTE: Advise students that the final step at the water treatment plant is to add disinfectants to the water to purify it and kill any organisms that may be harmful. Because the disinfectants are caustic and must be handled carefully, it is not presented in this experiment. The water that was just filtered is therefore unfit to drink and can cause adverse effects. It is not safe to drink!

EPA Publication #810/F-95-004, September 1995

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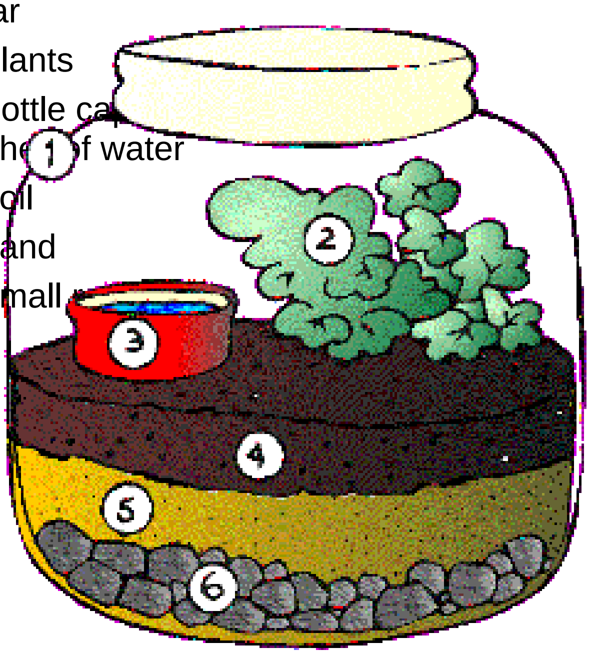
Make a Water-Cycle Model

Make a Water-Cycle Model

You will need:

1. jar
2. plants
3. bottle ca
   she f water
4. so l
5. s nd
6. small



Fill jar as in the picture and put the lid on. Put the jar in a sunny place and see how the water cycle works.

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The Water Facts of Life

Last updated: 01/23/97

Source:

United States Environmental Protection Agency
Office of Water
EPA 810-B-95-001
January 1995

Did You Know?

- There is the same amount of water on Earth today as there was 3 billion years ago.
- Three percent of the water on Earth is freshwater and only 1 % is available for human consumption.
- Sixty-six percent of a human being is water.
- Seventy-five percent of the human brain is water.
- Seventy-five percent of a living tree is water.
- You could survive about a month without food, but only 5 to 7 days without water.
- On the average, each American uses about 160 gallons of water a day at a cost of 27 cents.
- Bottled water may cost up to 1000 times more than municipal may not be as safe.

- Two-thirds of the water used in an average home is used in the bathroom.
- Typically 4 to 6 gallons of water are used for every toilet flush.
- On the average, a person uses 2 gallons of water to brush his or her teeth each day.
- A 10-minute shower uses about 55 gallons of water.
- A leaking faucet can waste up to 100 gallons of water a day.
- The average person spends less than 1 % of his or her total personal expenditure dollars for water, waste water, and water disposal services.
- There are about 60,000 community water suppliers in America.
- Pubic water supplies must meet or exceed Environmental Protection Agency standards. Many public water supplies consistently supply water that is much better than the minimum standards.
- The Amendment to the Safe Drinking Water Act in 1986 increased the number of contaminants to be regulated from 26 to 83 and expanded EPA's enforcement authority.
- If a drinking water supplier violates any federal standard, the utility by law must tell the customer.
- Current water treatment methods are designed to make drinking water clear and to kill germs.
- The pipes that carry drinking water from treatment plants to homes are regularly cleaned.
- It takes about 39,000 gallons of water to produce the average domestic auto, including tires.
- It is not safe for hikers and backpackers to drink water directly from remote streams.
- One gallon of gasoline can contaminate approximately 750,000 gallons of water.
- You can help prevent pollution of drinking water sources by carefully disposing of the chemical products you use in your home.
- An acre of corn contributes more to humidity than a lake of the same size.

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[Home] [Up] [Environmental Rulemaking] [Making Smog] [The Smoginator's Air Base] [Lesson Plan: Read My Data] [Radon in your home:] [Recycling Lesson Plan] [Composting Project] [Word Search Puzzle] [Cleanup of Hazardous Waste Sites] [Planning a School Yard Habitat] [Water Fit For A Bug] [Liquid Assets - Our Water Resources] [Build Your Own Aquifer] [Water Filtration] [Make a Water-Cycle Model] [The Water Facts of Life] [Water Waste Bloopers]

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Water Waste Bloopers

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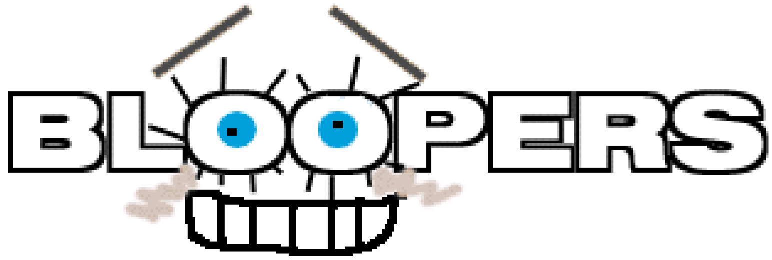


WATER WASTE & POLLUTION

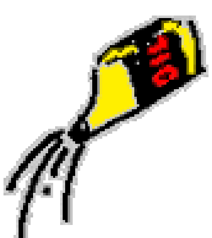
(Embarrassing Moments in the Life of a Water Drinker)

Waiting a week to fix a leak.

Assume little leaks only waste a little water? You can lose up to 200 gallons of water a day from a leaking toilet. And a faucet can drip 604,800 drops while you are waiting.

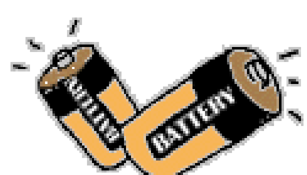
Taking a shortcut and using the hot water tap when cooking.

That's taboo, and it can shortcut your health. Lead can dissolve into hot water from lead pipes and solder. Cold water is better. Heat it on the stove when cooking or making baby formula.



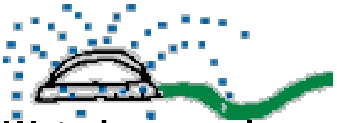
Slipping used motor oil into a storm sewer or burying it in the trash.

Hey slick, oil can leak into lakes, rivers, and wells. Just one pint can expand over an acre of water. Take your used oil to a recycling center.



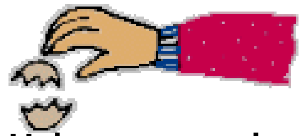
Tossing toxics in the trash.

How tacky! Consider batteries, a common throw-away. They contain lead and mercury. Some ordinary household cleaners have other poisons that contaminate water. Here's a tip, drop them off at a special collection site.



Watering your lawn at high noon.

Caught with your sprinkler on? The hot sun will evaporate the water your lawn needs. Better water early in the day.



Using your garbage disposal all the time.

Want to show good taste after a meal? With your disposal using one gallon of water a minute, you'll be creating a great soil conditioner.

Source: U.S. Environmental Protection Agency

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Office of the Secretary

P. O. Box 4301
Baton Rouge, LA 70821-4301
phone: (225)219-3953
fax: (225)219-3971

Legal Services Division
P. O. Box 4302
Baton Rouge, LA 70821-4302
phone: (225) 219-3985
fax: (225) 219-4068

Communication Division
P.O. Box 4301
Phone: (225) 219-3960
Fax: (225) 219-3971

Office of Management and Finance

P. O. Box 4303
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phone: (225)219-3840
fax: (225)219-3846

Human Resources Division
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Fax: (225) 219-3859

Financial Services Division
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Fax: (225) 219-3868

Procurement Division
Phone: 219-3827

Office of Environmental Services

P. O. Box 4313
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phone: (225)219-3181
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Environmental Assistance Division

Phone: 219-3296
Fax: 219-3309

Permits Division
Phone: 219-3181

Office of Environmental Compliance

P. O. Box 4312
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phone: (225) 219-3700
fax: (225)219-3708

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Fax: 219-3695

Enforcement Division
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Emergency Notifications:
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Office of Environmental Assessment

P. O. Box 4314
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fax: (225)219-3239

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Fax: 219-3474

Environmental Planning Division
Phone: 219-3235
Fax: 219-3240

Remediation Services Division
Phone: 219-3236
Fax: 219-3239

Regional Offices

Map of regions and office locations

Acadiana Regional Office

111 New Center Drive
Lafayette, La. 70508
phone: (337)262-5584
fax: (337)262-5593

Northeast Regional Office

1823 Hwy 546
West Monroe, La. 71292-0442
phone: (318)362-5439
fax: (318)362-5448

Bayou Lafourche Regional Office

110 Barataria St.
Lockport, LA 70374
phone: (985)532-6206
fax: (985)532-9945

Kisatchie Central Regional Office

402 Rainbow Drive, Bldg. 402
Pineville, La. 71360
phone: (318)487-5656
fax: (318)487-5927

Northwest Regional Office

1525 Fairfield, Room 520
Shreveport, La. 71101-4388
phone: (318)676-7476
fax: (318)676-7573

Southeast Regional Office

201 Evans Road, Bldg 4, Suite 420
New Orleans, LA 70123-5230
phone: (504) 736-7701
fax: (504) 736-7702

Southwest Regional Office

1301 Gadwall Street
Lake Charles, LA 70615
phone: (337) 491-2667
fax: (337) 491-2682

Laboratories

General Chemistry Lab

8618 GSRI Road
Baton Rouge, La. 70810
phone: (225)765-2405
fax: (225)765-2408

Air Toxics Lab

8000 GSRI Road, Bldg 402
Baton Rouge, La. 70810
phone: (225)765-0876
fax: (225)765-0048

Environmental Radiation Lab

4845 Jamestown Avenue, Suite 102
Baton Rouge, La. 70808
phone: (225)925-7042
fax: (225)925-1752

The Five Senses

Ollie L. Jamison
9340 S. King Drive.
Chicago IL 60619
(312) 785-0029

Delano Elementary School
3937 W. Wilcox Street
Chicago IL 60624
(312) 534-6620

Objective:

This lesson was designed for primary grades 1-3. The main objective of this mini-teach is to tell how important the five senses are: to name and identify the five senses; to demonstrate the ability to identify objects through the use of the five senses; to discover the sense of touch as a way to identify the smooth, rough, hard, and soft properties of an object; to discover that sounds and smells are a sources of information; we feel with our skin, we can recognize objects by their touch; and to demonstrate how sound is heard.

SIGHT

Materials Needed:

Use familiar objects from the classroom; horn toy, car, eraser, magnifying glass, marker, crayons, plastic ball and sea shells.

Strategy:

Line up objects on a table and ask the students to identify them. Tell them to close their eyes. While you remove one of the objects let them open their eyes and see if they can tell which object is missing. Let the children take turns playing the game.

The game may be varied in the following ways:

1. Increase the number of objects.
2. Remove more than one object from the group while the child is blindfolded.
3. Place objects in random order instead of in a straight line.
4. Add an object to the group instead of taking one away.
5. Let the child see the object. Blindfold the child and let him try to identify the missing object by feeling the remaining objects.

TOUCH

Materials Needed:

Blindfold, paper towel (Bounty)

Strategy:

Place small brown paper bags, numbered 1-8, on table with objects in each bag. Examples of objects are measuring spoons, candy eggs, sea shells, play turtle. The pupils are to guess what's in the bag by touching and feeling each bag.

TASTE

Materials Needed:

Various foods for a tasting party. Lime, lemon, oranges, plum, kiwi, grapefruit, peaches, salt and sugar mixed, cucumber slices.

Strategy:

A guessing game. Meet in a small group. Let students identify food by taste. Blindfold student, give him or her some food to taste and ask to identify the taste. Is it sour, sweet, salty, or bitter?

SMELL

Materials Needed:

Glass jar with lids, table, cotton balls, cologne (Eternity), black pepper, baby oil, shower gel, garlic powder, bleach.

Strategy:

Place objects in jars. Tell the students that they are going to play a guessing game. **YOUR NOSE KNOWS**: You are to identify each object by its odor.

HEARING

Materials Needed:

Metal spoon, wire hanger. 2 feet of kite string, ruler.

Strategy:

1. Tie the handle of the spoon or hanger in the center of the string.
2. Wrap the ends of the string around both fingers. Be sure that both strings are the same length.
3. Place the tip of your index finger in each ear.
4. Lean over so that the spoon or hanger hangs freely and tap it against the side of the table.

Results:

It will sound like a church bell because the metal in the spoon starts to vibrate when struck. These vibration are transmitted up the string to the ears. Objects must vibrate to produce a sound.

Performance Assessments:

TASTING Activity:

Answer the following questions:
1. Why do hot peppers make my mouth burn?
2. How many different flavors can I taste?
3. How do I taste food?
4. Why does my mouth water when I see or smell certain foods?
5. Why do I like some foods better than others?

SMELL:

Answer the following questions:
1. What are your favorite smells?
2. What smells make you hungry?
3. What smells make you sneeze or make your eyes water?
4. What smells make you think about being clean?
5. Where can you find many different smells?

Make a book about smells. Look through newspapers or magazines. Find pictures of things you like to smell. Cut out pictures and tape or glue them onto pieces of paper. Fasten papers together to make a book "Things I Like To Smell."

HEARING:

Answer the following questions:
1. Why do my ears pop in an airplane?
2. What is sound?
3. How do I hear?
4. Can I hear things when I'm asleep?
5. How do deaf people communicate?
6. How well can animals hear?

Conclusion:

At the conclusion of this mini-teach the students will be able to identify the five senses, and relate these five senses to everyday life.

OUTSIDE ACTIVITY:

Name, identify and describe objects that are related to the five senses.

Smell	Touch	Seeing	Hearing	Taste

Return to Biology Index

SMILE
Quick Links

- [Academic year](#) class notes
- [High School](#) Bridge contest
- [Contributed](#) lessons
- [SMART program](#) home page
- [Web based](#) resources
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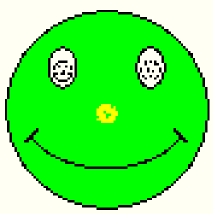
-SMILE-

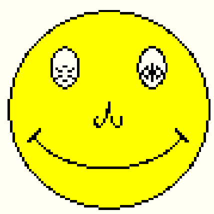
Science and Mathematics Initiative for Learning Enhancement

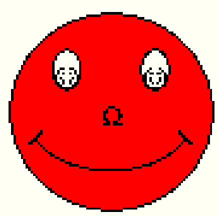
The SMILE program is designed to enhance the elementary and high school learning of Science and Mathematics through the use of the phenomenological approach. For a brief course description/syllabus click here.

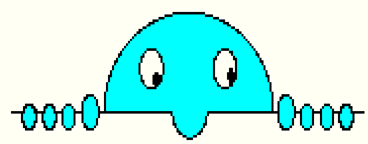
Between 1986 and 1997 each summer session participant was asked to create and publish a single concept lesson plan. These lesson plans include the materials needed, a suggested strategy and expected outcomes. There are currently almost 900 of these lesson plans available (see subject indices below). In addition, starting in 1997 the participants in the academic year program have been asked to present a brief single concept lesson or idea. Summaries of the academic year lessons are at academic year notes. All of these lessons are available in the following formats:

1. A book of each summer's lessons. The cost of a book of all of the lessons developed during a single summer is $10.00. Contact Dr. Porter Johnson (312) 567- 5745, Dr. Ken Schug (312) 567-3438 or the departmental office at IIT (312) 567-3480 for availability.
2. A CD-ROM with all of the lessons (summer and academic year) and links from both this and the SMART web sites for $15.00US to a US address ($20US outside the United States). Contact Roy Coleman at Morgan Park High School (773) 535-2550 for availability.
3. Listings by subject are available by linking to any of the following:


Biology


Chemistry


Mathematics


Physics

Awards and Reviews

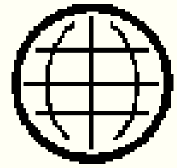
Education Planet	Schoolzone International	NSTA Scilinks

StudyWeb	Big Chalk	Actionbioscience
Wired Patrol	Psigate	Schoolsnet

NOTE: If the following looks really bad or your browser doesn't support tables, try the old home page.

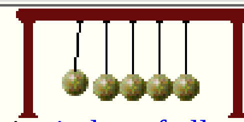
If you have a single concept lesson that you think might fit in with the SMILE concept or would like to see some lessons which have been contributed by persons other than SMILE participants jump to contributed lessons	SMILE has bi-weekly classes during the academic year and we are posting the notes from those classes. If you are interested, jump to academic year notes.
The SMILE PLUS program is a program designed for intensive training of a team of teachers who are from the same school. These teachers then go back to their home schools to provide inservice training for the remainder of the faculty and staff.	This section includes some general information developed by the SMILE program. • Information on Science Fairs: How to start and run a Science Fair, Chicago Public Schools Science Fair information and NEIU's Science Fair Central. • Sources of reference material • Sources of hands on science equipment in the Chicago area

Photos of the 1997, 1998, 1999 and 2000 SMILE participants in action.



Web Addresses of internet sites for general interest in Science.
IIT will occasionally offer Saturday classes for teachers and students on the World Wide Web and searching the Internet. For more information, contact Dr. Porter Johnson

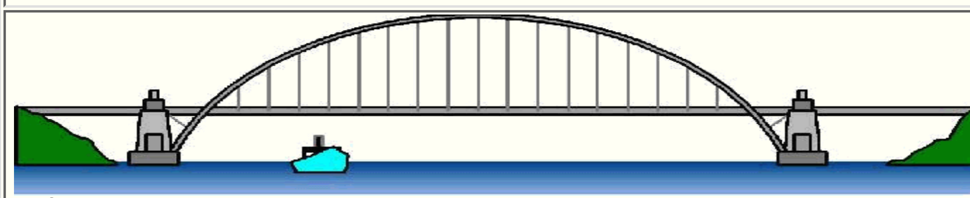
Fall 2004 schedule of classes.
First class and registration will be September 14.
Visitors are welcome to sit in on many of the classes.



The entire index of all sections is also available for you to search with your browser. However, be aware that this index is about 100K and takes a while to transfer.

Additional lessons can be found on the SMART website.

The SMART program is made possible by a generous grant from the Lucent Technologies Foundation.



Information on the High School Bridge Building Contest is available at the 'hsbridge' website.

NOTE: The area code of most of Chicago is now 773. IIT, however, is still in the 312 area code.

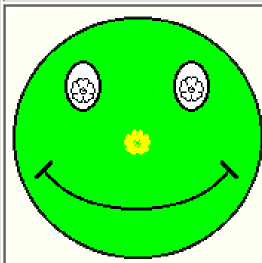
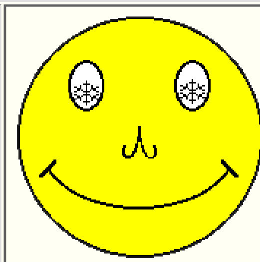
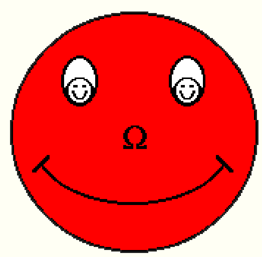
Email address: smile@iit.edu

Address: Smile Program - Dr. Porter Johnson
IIT-Dept of Biological, Chemical and Physical Sciences
IIT Center
Chicago IL 60616
Phone: (312) 567-5745
Fax: (312) 567-3494
Email address: Porter.Johnson@iit.edu

You are visitor  since March 1, 1997.

Please sign our visitor's book.

Last update Monday, May 31, 2004 by Roy.Coleman@iit.edu
Animation courtesy of http://www.dewa.com/animated and http://www.iconbazaar.com

The 'Founding Fathers' of SMILE			
 Biology Ben Stark	 Chemistry Ken Schug	 Mathematics Art DiVito	 Physics Earl Zwicker

(Move mouse pointer over icon)

ILLINOIS INSTITUTE OF TECHNOLOGY

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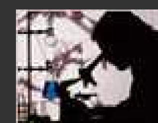
IIT SPOTLIGHT current news & events



IIT Awarded $5 Million for Biomedical Complex

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Institute of Psychology | Stuart Graduate School of Business

Updated on August 25, 2004

Mathematics/Physics

Introduction To The Periodic Table

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Objective(s):

The purpose of my mini-teach is to introduce various methods of presenting the Periodic Table which identifies the various elements. I will also be introducing some terms and common phrases used in American Sign Language because most of the students I work with are Deaf and Hard of Hearing and I think that it would be most beneficial for the instructors to become familiar with these terms in the event that some Deaf and or Hard of Hearing students are in their classes.

The students will be able to identify the scientist who first wrote the Periodic Table

The students will be able to identify the scientist who amended the Periodic Table

The students will be able to state (or write) specific data relating to the history of the Periodic Table

The students will identify at least five elements which have been represented on the Periodic Table

The students will identify at least two components of the Periodic Table (Metal or Non-Metal)

TITLE: **SCIENCE IN SIGN, PART XVII.**

-

INTRODUCTION TO THE PERIODIC TABLE

-

GRADE LEVEL: 9 – 12 AS WELL AS ELEMENTARY GRADES

Materials:

1 LG. PERIODIC TABLE

1 TV/VCR

1 MOVIE ’THE PERIODIC TABLE’

HANDOUTS ‘THE PERIODIC TABLE’

HANDOUTS ‘THE ZAGHOUSE’

PAPER CUPS

TOOTH PICKS

GUM DROPS

MAGIC MARKER

CHALK BOARD

-

Strategy:

I will begin my presentation by stating my name and finger spelling my name simultaneously.

I will introduce my presentation as Science In Sign part 17 and give the name of my

Presentation “An Introduction to the Periodic Table”.

There will be ten words listed on the chalkboard “VOCABULARY” which I will “sign”

for the students and have the students “sign” after me first and then by themselves.

Once the students have completed the vocabulary, I will explain the brief information to be presented in the movie “The Periodic Table’ (10 min.).

After the movie has been shown, the students will be given their copies of the Periodic

Table and we will discuss the scientists referred to in the film and what promoted each to begin his work. (8 min.)

The students will be given one package of characters, each facing different directions, the hair, fingers, legs, and/or facial expressions will indicate which column it belongs to.

The students will be told that each character must be placed in order by the identifying

Characteristics.

The students will be able to see, once characters are in order, the Periodic Table will be completed. The students will discuss the Zag House for five or six minutes. Remember, science has no definite order.

The culminating activity is that the students will create elements represented on the Periodic Table

Each student will be given several toothpicks of varied lengths, gum drops (at least 20), plastic containers, and element work sheet which will identify specific elements which are to created using the gumdrops. Each student will complete their elements and tell the class what the elements are, identify the number of protons and neutrons in each element (i.e. Hydrogen=1 proton, therefore, the tooth pick would only have one gum drop on it).

The time allotted for this activity will be 15 minutes.

Performance Assessment:

-

The students will complete a quick quiz sheet identifying specific elements and the names of the scientists named in the movie.

There will also be time allotted for questions and answers, critique, and methods to improve and/or change the presentation.

Conclusion:

I will conclude my presentation by asking specific students to sign the vocabulary words which were presented at the beginning of the session, ask the names of the two scientists named in the movie, and remind them that as educators/ teachers in the main streamed class room, we must always use various methods to introduce topics such as the Periodic Table in ways which will hold the students interest and their attention.

I will also emphasize that science is one of the most difficult subjects for students who are Deaf, Hard of Hearing, and Hearing Impaired and that there may be times that the language and the method in which the lesson is present should be modified to meet the students' needs and assure their comprehension of the subject matter. This will also assure the instructor that the student is 100% or at least 99% confident that he or she will pass the class or at least leave with a good working knowledge about the subject.

Rubric:

Because class participation is a prime factor, the students will receive 25 points extra credit for completion of both activities

-

QUIZ (10 QUESTIONS)

10 POINTS PER QUESTION

100—90 A

89 ---80 B

79 ---70 C

69 ---50 D

BELOW 50 MEANS THAT THE STUDENTS NEED MORE TIME ON ASSIGNMENT.

REFERENCES;

-

A Basic Course In American Sign Language Humphries, Patton

-

Dorlene Kindersley Science Encyclopedia A Dorlene Kindersley Book

-

Experience in Physical Science Myonsli

WebElements

Pictorial Periodic Table

Film: The Periodic Table The Proctor Company

-

Science in Sign (Science and Math Resource for Teachers R.I.D.

-

Addendum:

-

Academic State Goals

Chicago Academic Standards

Chicago Framework Standards

State Goal: 11 **State Goal: 12**

CAS: B CFS: 2, 4, 7, 13 **CAS: C CFS: 1**

-

Special thanks to: Carl, John and Earnest.

Marjorie Fields - Ella Flagg Young

Tempting Temperatures

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Objective(s):

The students (K-3) will be able to define what a thermometer is and observe changes in temperature using a thermometer.

Materials Needed:

Two thermometers, two empty pop cans labelled A and B, water, measuring cup, and a refrigerator with a working freezer, stop watch or clock with a second hand

Strategy:

Day 1
Fill each can half full of water
Place Can A in the refrigerator and Can B in the freezer
Make a chart
The chart should show the temperature of both thermometers before they are inserted into the cans. Times are charted at five minute intervals (5 minutes, 10 minutes, 15 minutes).

Day 2
Remove both cans from the refrigerator/freezer
Leave both cans out for one hour
Before conducting the test get out your chart
Write on the chart the temperature of the thermometer before it is inserted into the cans
Place the thermometers in the holes at the top of the can
Record the temperatures on your chart after 5 minutes, 10 minutes and 15 minutes on your chart

Performance Assessment:

Using the chart students should be able to fill in the appropriate numbers and symbols that represent temperature and orally explain their observations.

Conclusions:

Using the exam below (Note:This can be administered in written form or orally), students should be able to obtain 80% mastery.

1. How many cans were used?
2. How many thermometers were used?
3. How much water was put in each can?
4. Where was Can A placed?
5. Where was Can B placed?

6. On day 2, how long were the cans left out in the classroom?
7. How do you write 70 degrees? (Teacher directed)
8. Was there a difference in Can A and Can B after 5 minutes, 10 minutes and 15 minutes?
9. What were the differences?
10. Ask students what did they learn from this activity?

References:

Fields Book of Science for Early Education Students '99.

Return to Physics Index

Air: Demonstrating Its Presence and Effects

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Illinois Institute of Technology
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Objective:

To examine the effect of air pressure in a series of experiments that highlight the consequences of the presence of our atmosphere, aimed at grades 6-12.

Materials Needed:

1. A supply of sturdy 6" or 9" balloons [available at "party stores"]
2. Heat Source [hot plate or Bunsen burner], tongs
3. A supply of aluminum soft drink cans, a water bucket
4. Heavy flat smooth rubber mat material [available at American Science Center]
5. String, heavy scissors, metal washers, metersticks, stopwatches
6. A supply of coffee filters, tea bags, matches
7. Stick and propeller blade [available at American Science Center]

Strategy:

We live at the bottom of a 10 km ocean of air. The density of air is about 1/1000 that of water, so that air pressure corresponds to the pressure of a water column of 10 meters [40 feet]. In these experiments we examine the effects of air pressure.

Ethnic Rocket Launch: Remove the cord and staple from a dry tea bag [Lipton or other unflavored] and empty its contents. Form the bag into a hollow cylindrical "silo" and stand it erect. Light the top of the bag. The bag will burn quickly with little residue. As fire reaches the bottom, the bag will rise. A column of warm air aids the launch, which can be quite spectacular.

Dropping Coffee Filters: Modern physics began when, some 500 years ago, Galileo Galilei dropped metal balls of different sizes from the "leaning tower" of Pisa, and observed [or at least claimed to see] that they hit the ground at the same time, in contrast to expectations that the heavier ball would fall more quickly. Galileo had in mind neglecting air resistance.

By contrast, when an empty coffee filter [Mr Coffee or clone] is dropped [nose pointing down], air resistance is not negligible. Drop a coffee filter from heights of one meter and two meters, and measure how long it takes to hit the ground. [We observed that it took circa 1.15 seconds to hit the ground from one meter, and about 2.30 seconds from two meters.] Note that, as the distance is doubled, the time required also doubles. This is an indication that, for most of its travel, the filter is moving with constant speed, the force of gravity [downward] being balanced by air resistance [upward].

Next, put several filters together, so as to increase the mass of the system, while keeping its profile fixed. Measure the time for several coffee filters to fall. We observed the following times from a height of 2 meters:

Number of Filters	Time

1	2.30 sec
2	1.60 sec
3	1.30 sec
4	1.15 sec

We saw that one coffee filter falls through one meter in the same time as the four coffee filters took to fall through two meters. Drop them simultaneously to determine whether they hit at the same time. **[Note: the force of air resistance appears to be a quadratic function of the velocity of the filter.]**

Crushing the Can: Put about 50 cubic centimeters [2 ounces] of water in the bottom of an aluminum can. Heat the can until the water inside begins to boil. Then, take the tongs, turn the can upside down, and push it directly into the water in the bucket. Observe the resulting collapse of the can. The air inside the can has been displaced by water vapor, which condenses when the can enters the cool water. Air pressure on the outside pushes the can inward. This crushing force of air pressure is always present in our environment.

Rubber Mats: Get a supply of heavy flat smooth rubber mat material [about 3-5 mm thickness]. Cut the material into rings of diameter about 30 cm with heavy scissors. Punch a hole through the center of the disc, and push a fairly heavy string through the hole. Tie a metal washer to the string, so that the string will not pull back through the hole. Place the disc on a smooth solid surface, and press the air out from under the disc. Pull up on the cord. If the seal is properly made, you will not be able to pick up the disc with the cord, because you must overcome air pressure [approximately 15 pounds per square inch, or 10000 kilograms per cubic meter].

Measuring Lung Volumes with Balloons: Have every member of the class take a standard 9" balloon, making it limber by blowing it up a few times. After some practice, each class member should fill his/her lungs, expel one full breath into the balloon, and measure the diameter of the balloon. **[Note: Not everybody knows how to blow up a balloon!]** Calculate the volume **V** of the balloon [assume a spherical shape] from its diameter **D** using the formula:

$$V = PI\ D^3 / 6$$

where PI = 3.1416, and D^3 is "**D**-cubed". Then, record the age and height of each participant. Here is a data table for the current SMILE class.

LUNG VOLUME TABLE

Participant Number	Age (years) **A**	Height (in) **H**	Diameter (cm) **D**	Volume (liters) **V**	Fit Volume (liters) **V-fit**
#1	54	71	17	2.57	2.58
#2	37	64	18	3.05	2.85
#3	60	66	17	2.57	1.91
#4	28	70	20	4.19	3.75
#5	28	56	14	1.44	2.66
#6	42	62	15	1.77	2.46
#7	7	40	18	3.05	2.43

The last column in the table is calculated from a "least squares" fit to data with the formula

$$V = -.048 A + .078 H - .353 .$$

The standard deviation of this fit was **+/- 0.66 liters**. A variation of this method of measuring lung volume and comparing with standard formulas is used by medical clinicians to detect lung damage.

Helicopter Blades:

Attach a light plastic propeller to a stick. With the propeller held up, launch the stick by giving it a spin and throwing it up in the air. Depending upon the direction of the spin, the rocket will either accelerate upward, or else plummet to a quick crash. Try launching the rocket with the propeller pointed down, and note the direction of the spin in relation to its motion.

Performance Assessment:

In medieval times in the city of Magdeburg [in Saxony Province; formerly East Germany], two metal hemispheres of diameter circa **30 cm** were connected through an airtight seal, and the air was pumped out of the interior. Teams of horses were then connected to each of the hemispheres. The teams of horses could not pull the hemispheres apart. Using the concept of air pressure, explain this result.

Conclusions:

The effects of air pressure are sometimes subtle and sometimes dramatic. There is a wide variety of classroom demonstrations of the existence of air and its effect in our environment.

References:

Robert E Ehrlich **Why Toast Lands Jelly-Side Down**
Zen and the Art of Physics Demonstrations
[Princeton 1997] Paperback: ISBN 0-691-02887-7

Return to Physics Index

Density

Marilyn Martello
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Park Ridge IL 60068

Clinton
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Objectives:

Grade 6-8
To discover what properties determine the phenomenon of objects able to float and objects able to sink.
To identify these properties as mass and volume.
To apply density to the three different types of matter: solid, liquid, and gas.

Materials Needed:

For 4 groups of 4 students:
8 objects that will float, 8 objects that will sink (it is important that the objects chosen should differ greatly in density so that when you plot your graph, the objects which float should be way below water density and the objects which sank should be way above the density of water)
4 plastic pails filled 3/4 with water
2 scales with measurements in grams
4 beakers with these measurements: 200ml, 500ml, 1000ml, 2000ml
3 graduated cylinders measuring 25ml, 100ml, 1000ml
4 oz cooking oil, 4 blue colored ice cubes
12 oz clear glass

Strategy:

In the 12 oz glass, put in oil and ice cubes and set aside. Choose an object which will float and one which will sink. Tell the class you have two objects you want them to observe. Drop them into a clear beaker filled 3/4 way with water and ask what happened. Students will suggest that weight is a factor that made one object sink. At this point instruct the class to divide themselves into groups of 4, come and choose an object of their choice, weigh their object, put the object in water, and record their findings on a chart on the board as follow:

Name	Object	weight	sink or float

After everyone had recorded their findings, have the class look at the chart to find any type of pattern (there won't be any). Guide the class to discover that volume of an object is another factor that needs to be explored. Show how to measure the volume of an object by displacement of water using a graduated cylinder. Drop an object into the cylinder filled 3/4 way with water. The water level will rise. Tell the class that they are to mark the water level before and after the object has been dropped. Take the difference between the two markings and record it on the column marked volume on the board (add a volume column to the chart). When everyone has completed their data, explain to the class that they have found the density of their object. Write the formula on the board: Density = Mass/Volume or D = M/V. Using the data from the chart, construct a graph plotting the volume vertically and the mass or weight horizontally. Ask if anyone sees a pattern as to why some objects floated while others sank (again there is none). Point to the fact that we need to plot the density of water on the graph also because the objects were floating in that medium. Help the class measure and weigh water using different amounts 3 times and plot the data on the graph. Draw a line connecting the water "dots" on the graph. Ask the class to look at the graph again. Using the information on the graph, ask if anyone can now explain why some objects floated and why others sank. If no one has the correct explanation, circle the "dots" of the objects which floated (they should all be above the water line). Point to the fact that all the floating objects are above the water line and the ones which sank are below the line. In other words, objects less dense than water will float and objects more dense than water will sink. Apply this concept to gases. Ask the class why does a balloon filled with helium floats in air (helium is less dense than air therefore it rises).

Performance Assessment:

Show the class the 12 oz glass containing the oil and ice cubes (the ice should have melted enough to form a blue fluid accumulation at the bottom of the glass).
Ask: Which fluid is more dense, the oil or the blue water?

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Air Movement

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Objectives:

To understand the existence and movement of air. Designed for grades 5 through 8.

Materials Needed:

air cannons
apples
tape
plastic bag
kleenex
a book
playing cards
a bowl
colorful smokebombs
a cup
a piece of paper

Strategy:

Teacher will walk around the room with an air cannon. Teacher places items on top of the head of someone and knocks it over with the air cannon. Teacher hits the air cannon, so that air will touch someone. Teacher will ask students, what is inside of this object? Wait for responses. Talk to students about air being everywhere. That it is all around you, even things that look as if they are empty are really full of air.

Experiment 1: Teacher will tape two apples on strings from a door frame or from something else. They should hang about 3cm (1in) apart, and level with your mouth. Wait until the apples are steady then blow hard between them.

Question? Do the apples move apart or together? Why?

Answer: When you blow, you make air between the apples move. This moving air has less pressure than the still air on either side of them. So the still air pushes the apples together.

Experiment 2: Teacher will hold a plastic bag open, pull it through the air to trap some air in it, then close it. Tell the students that you can't see the air in the bag but you can feel how firm and squashy it is.

Question? If you have an empty bag, does it have air in it?

Answer: Yes, air is everywhere, even though you can't see it.

Experiment 3: Teacher will put bits of kleenex on a flat surface and drop a book on them. The bits of paper blow away because the falling book pushes air out of the way and makes a wind.

Question: Does air move things?

Answer: Yes, air moves and vibrates things.

Experiment 4: Teacher explains that air not only moves things, it can also slow things down that move through it. Ask two volunteers to come up and stand on chairs. Below them place a wide bowl. Hand each student some playing cards. Have one student drop their cards end up. Have the other student drop their cards face down.

Question? Which cards fell in the bowl the most? Why?

Answer: The cards dropped faced down usually landed in the bowl because the air pushing up beneath it escapes fairly evenly all around it, so it falls straight down. The card dropped end up, swoops to one side.

Experiment 5: The teacher will take an empty glass (let the students observe the empty glass) and submerge it into water. The teacher will ask students to predict whether or not the paper inside the glass will get wet or not.

Question? Why didn't the paper get wet?

Answer: The air keeps nearly all the water out. (Teacher can tilt the glass to show water going into the cup)

Experiment 6: The teacher will divide the class into groups of a number that will vary. Each group will be given an air cannon. Inside the air cannon will be a colorful smoke bomb. Each group will go in an open area and take turns shooting their air cannons. All students should observe the colorful smoke rings, which are air.

Performance Assessment:

Students will list 3 things that they have learned about air.

Return to Physics Index

Gases Lighter and Heavier than Air

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Libby School Annex
5338 S. Loomis
Chicago IL 60609
(312) 535-9350

Objective:

This lesson was designed for students in grades 2-4.
The students will be able to understand and demonstrate that there are gases that are lighter (less dense) and heavier (more dense) than air.

Materials Needed:

Winnie the Pooh storybook, Jensen bars, Helium balloons (already filled), Balloons, Vinegar, Baking soda (about 2 Tbs. for each child, wrapped in a piece of light weight paper), Plastic drink bottles (12-16 oz. size), Small (4") pictures of Winnie the Pooh, 12" lengths of fine monofilament line

Strategy:

Tell children the story "We are Introduced" from **Winnie the Pooh**. Discuss how Pooh got up in the air and ask if the children would like to try to make Pooh Bear fly. Distribute empty balloons, monofilament and pictures of Pooh. Let the children try to make Pooh fly and ask what they observe. Why can't Pooh fly? Ask for suggestions for how to help Pooh.

Distribute monofilament and pictures of Pooh, then bring out helium-filled balloons. Let the children now try to help Pooh fly, but try to control his flight so he doesn't end up on the ceiling! Record the children's observations. They should be able to conclude that a helium-filled balloon is lighter (less dense) than an air-filled balloon, and being lighter than air will help a helium-filled balloon to float up.

Tell the children that they can make another gas to fill a balloon. Do not tell them that the gas will be heavier (more dense) than air. Distribute the plastic bottles filled 2/3 with vinegar, paper packages of 2 Tbs. baking soda, and empty balloons. Demonstrate how to fill their balloons with gas -- place the paper folded with the baking soda in it into the bottle, then put the balloon over the lip of the bottle. As the paper unfolds and exposes the baking soda, the balloon fills with gas. Tie the balloon off when it is full. As the children compare the balloons they have filled, they will find that their newest balloon is heavy compared to both other balloons. Identify the gas they made as carbon dioxide. Let the children work in groups of 3-4 with Jensen bars to compare their balloons. Record their observations. They will discover that carbon dioxide-filled balloons are much heavier than air-filled balloons. Children should be able to conclude that carbon dioxide is heavier (denser) than air.

Performance Assessment:

All children should be able to verbalize that not all gases are the same weight, that some gases are lighter (less dense) and some heavier (more dense). Some children will be able to name the gases helium and carbon dioxide and to indicate which is more and less dense compared to air and to each other.

Children can draw pictures of Winnie the Pooh holding each balloon. The placement of the balloons in relation to Pooh indicates the understanding of the concept of gases lighter and heavier than air.

References:

Winnie the Pooh, A.A. Milne
Winnie the Pooh, story adaptations and song book, Walt Disney Productions
Storybook Science:Innovative Hands-On Science In Your Primary Classroom, R.S. Cichowski

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States of Matter

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Objectives:

This lesson is designed for students in grades 1 - 3.

1. To understand the meaning of the words solid, liquid, gas.
2. To provide concrete experiences with solids, liquids and gases.
3. To understand that solids, liquids and gases are all forms of matter, and that matter is anything that takes up space and has weight.
4. To gain an initial exposure to the concept of molecules.

Materials Needed:

(for Activity #1) paper cup, zip-lock baggie filled with water, two empty zip-lock bags, pencil, a solid object such as a rock or a ball; (for Activity #2) 3 balloons for each group: one filled with frozen water, one with water, one with air, one scissors for each group, one empty bowl, chart paper and markers for each group; (for Activity #3) small pieces of paper in three different colors, one for each child in the class; (for Activity #4) vinegar, alka-seltzer or baking soda, one-hole stopper and clear bottle, a second clear bottle, rubber tubing (about 8 inches) or 2 flexible straws taped together.

Strategy:

Activity #1: Hold up a zip-lock bag containing the solid (rock, ball, etc.) Introduce term "solid" Take it out. Ask children to feel it, look at it, etc. Does it take up space? Does it have weight? Does it keep its shape? Ask for other examples of solids, other properties of solids suggested by children; record on chart or board. Hold up baggie with water. Introduce "liquid". Pass around. Does it take up space? Can you see it? Does it have weight? Does it keep its shape? (Pour water into cup so children can see that the liquid takes the shape of its container.) List other liquids, discuss their properties, record on chart or board. Blow air into third, empty baggie. Discuss with children. What's in the baggie? Does it take up space? Does it have weight? (Accept the answer"no".) Does it keep its shape? (Let air out of the bag and ask children where it went.) Discuss other properties, other gases, if any, that children may know the names of. Let them inhale and see how lungs expand like a balloon. Review from board or chart properties of solids, liquids, gases.

Activity #2: Pass out to each group the materials for Activity #2. Tell children they are going to investigate the contents of the three balloons and write their observations on chart paper. They will feel the frozen balloon, cut the rubber off with a scissors. Discuss what they see and feel. Do the same with the water balloon, observing the properties of the water both when it is in the balloon and as they pour it into the dish or bowl. Record observations. Feel balloon with air. Let air out. Write observations. Encourage use of descriptive words such as "hard, invisible, wet, splashy," etc. discuss all observations of all groups. Combine onto large chart with the three headings of solid, liquid, gas. Try to accept all observations as valid.

Activity #3: Begin by telling the children that all matter is composed of tiny particles called molecules. Pass out colored papers. Have all children with "yellow" come up and demonstrate what the molecules in a solid might look like. (Packed very tightly together; this is why a solid keeps its shape and may feel hard). The next group of children ("blues") come up and demonstrate how the molecules of a liquid act (farther apart' moving, which allows us to pour a liquid). Third group demonstrates molecules of a gas (far apart: moving rapidly)

Activity #4: Explain that children will see how another gas, carbon dioxide, takes up space. (Gases are hard for children to deal with since they are invisible; children will need several experiences that demonstrate that air takes up space.) Fill one bottle to the top with water. Put baking soda or alka-seltzer in second bottle; add vinegar, then quickly stop up the bottle with the stopper, which has the hose or straws inserted in it. Place the other end of the hose or straw in the bottle of water and observe the action of the carbon dioxide as it is released in the water. (The reaction lasts for only a short time) Discuss what happened, why, and what we learned about the gas.

Performance Assessment:

1. Use the observation charts from Activity #2
2. Ask small groups of children to play-act what the molecules in a block of ice might look like as the ice begins to melt.
3. Have separate properties written on sentence strips or large pieces of paper. Children must take the property-strips and put them under the headings of "Solid", "liquid", or "gas".

Conclusions:

I had found an experiment in several books that showed how to "weigh air" I found out that these experiments are misleading and wrong. You can't weigh air! At least, not the way these books tell you to. So beware of "weighing air" experiments!

References:

Science on a Shoestring
Scholastic's **Big Science: Matter**

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Temperature

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Objectives:

Students in grades kindergarten through second will learn that the skin is not always a reliable sensor of temperature.
Students will learn how to read a thermometer.
Students will practice using a thermometer to determine a specific temperature.
Students will observe that dark colors absorb heat faster than light colors.

Materials Needed:

hot, warm, and cold water in three separate bowls
towels
thermometers (one per child or one for every group of two children)
styrofoam cups (one for each group of two)
water
colored construction paper
crayons

Preparation:

Put a piece of tape over the numbers of each thermometer.
Put a color of construction paper on the inside and outside of each styrofoam cup.
Prepare a graph illustrating the colors used across the bottom and the temperatures in fahrenheit along the side.

Strategy:

1. Set out the three bowls of hot, warm, and cold water and invite one child to tell you which one is hot, warm, or cold. When the child has accomplished this, ask the class what the student used to tell the temperature of the water. When they acknowledge that the child used her hands, ask them if they think our sense of touch is a good way of telling the temperature of something? Tell them that we are going to find out.

2. Have each child put one hand in the hot water and one in the cold water. Have them hold it there for a few seconds. Next, have them put both hands quickly in the luke warm water. Ask them to concentrate on what each hand feels and be prepared to describe what they have felt after everyone has had a turn. After each child has had a turn, discuss what the water felt like to both hands. The children should have noticed that the warm water felt cold to the hand that was in the hot water and felt warm to the hand that was in the ice cold water. Discuss the differences and ask if they still think that skin is a good sensor of temperature.

3. Ask if there are any other ways to reliably measure the temperature? Discuss each idea and then tell the children that you have a thermometer. Give

each child a thermometer with the numbers covered. Allow every child to put their thermometer into the hot water and the cold water; marking a line on the tape where the red indicator stops. Discuss what happened to the thermometer when it was placed in the two different temperatures of water. Have the children take off the tape on the Fahrenheit side and discuss what they see. Have them read the number across from their mark and compare their answers. Their answers should be relatively close. Discuss why a thermometer is a more reliable sensor of temperature than our sense of touch.

4. Tell the children that they are going to get a chance to actually measure the temperature of water when it is placed in the sun. Have the children get into groups of two. They will need one thermometer, a styrofoam cup, and some water in their cup. Make sure that all thermometers start at the same temperature by placing them in a cup of water with ice. Have the children put their styrofoam cups filled with water outside in the sun and place their thermometers in the water. Leave the cups outside for 30 minutes. When the children bring their equipment back inside, have them take a final reading and put their results on the class graph according to their specific color. Discuss the graph. Which color had the highest temperature? Which color had the lowest temperature? Ask the children if they can explain what happened. (Black or dark colors absorb the light energy of the sun and it is changed to heat. Light colors act as reflectors and bounce light off.)

Performance Assessment:

The students will color in a given thermometer to show 80 degrees Fahrenheit. Next, they will write and illustrate what color clothing they would wear to school on a very hot, sunny day.

References:

Primarily Physics Grades K-3, AIMS Activities

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Exploring the Properties of Matter in the Preschool

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Objectives:

Increase awareness of their immediate physical and natural world through manipulation, observation, discussion, art, and hands-on experiences.
Increase the ability to observe and describe events and objects.
Increase the ability to compare events and objects.
Increase the ability to notice and describe changes.
Experience activities that clarify a cause and effect relationship.
Practice making inferences based on observations and experiences.
Practice making predictions about changes and causal relationships that can be verified by further exploration.
Encourage enjoyment, curiosity, exploring, questioning,and using resources.
The emphasis of this curriculum is upon active involvement and questioning about the world. Therefore, it is not limited to specific science activities, but rather is an approach to all experience.
The teacher plays an important role in modeling curiosity and exploration and by posing questions that can lead to further activity and discovery. The teacher must plan appropriate activities that are not too complex or abstract and must help the children organize information in such a way as to highlight patterns and relationships.

Materials Needed:

Sensory/Discovery Table Materials: pulleys, rope, sand, clear plastic 20 ounce soda pop bottles, cup hooks, lumber, twigs, stones, straw, glue, sand and water table objects - i.e. funnels, sieves, water/sand wheels, various objects for sinking and floating experiments, fresh eggs, cream, vinegar, lemon juice, writing scribes and writing materials, kitchen tools - i.e. potato peeler, knife, various types of can openers, guest speakers/demonstrators, science books, ice cubes, sand and water.

Strategy:

At each Learning Center children, are encouraged to interact with each other, with teachers, and with a variety of materials. Through these interactions, children can develop a complex set of language, cognitive and social skills. They can learn how to share feelings, ideas and how to negotiate and solve problems. In the process they naturally compare and contrast the properties of matter. Filling the Sensory Table with different materials offers children varied opportunities for sensory and motor exploration. They can experiment with different textures as the materials used change. Use a bulletin board or pictures on the wall next to the table to reinforce the concepts being experienced by the children.

Demonstrate how tools and machines help make tasks easier to perform - eg. show how the pulley moving the weight of two heavy sand filled bottles makes work easier. The physical environment sends messages to children through the materials selected. The goal is to encourage and support talking, the environment must be filled with things of high interest and involvement -- so that children have lots to talk about. It is in a play environment that children are able to sequence their own learning and move at their own pace. Play environments are more likely than work environments to permit the exploration of materials other than paper and pencils. Children playing have access to the concrete world in all its diversity and to other people with whom they can test both their ideas and social skills. To work well, it has to offer children plenty of interesting choices, clearly organized and accessible.

Performance Assessment:

Ask the question, "What will happen if---? "
Explore the possibilities!!!!!

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The Air Out There

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Objectives:

The elementary student will be able to;
demonstrate air movement.
indicate the direction of the air.
measure the speed of the air in different areas.

Materials:

1. scissors, square sheet of paper, straight pin, pencil with eraser, piece of crepe paper

2. tagboard, compass, felt tip pen, juice bottle, straw

Strategy:

The students will divide themselves into two groups. Group One will construct a windmill using the following directions: Fold the paper square diagonally. Fold it again. Now, when you open the paper and lay it flat out, it will have an "x" creased through it. Cut along each fold within one inch of the center. Pick up one corner and hold it in the center. Do this with each corner and staple. Stick a pin through the center and attach to an eraser. Mark one of the blades with a small streamer.

Group Two will construct a weather vane following these directions: Cut the shape of an arrow with a long narrow tab from the tagboard. Curve the tip and insert the tab into the end of a straw. Insert the straw into the juice bottle. Mark the directions N, S, E and W.

Have both groups proceed outside and break up into groups of two so that one person will have a windmill and one person will have a weather vane. The windmill will measure the speed of the air by counting the number of times the sticker passes the pencil. The weather vane will point and indicate the direction of movement.

Performance Assessment:

The participation and data collection of each student.

Conclusion:

Air does move, the speed can be measured and the direction can be calculated.

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Comparing Densities of Different Liquids

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Objectives:

1) To motivate students to experiment, observe, and calculate densities of several different liquids.
2) To understand that density is the ratio of the mass of a substance to its volume.
3) To be presented with adaptations in grades 4-8.

Materials needed:

1) Equal quantities of the following liquids:
   Liquid A (water)
   Liquid B (water plus red food coloring)
   Liquid C (water plus blue food coloring)
   Liquid D (dark Karo corn syrup)
   Liquid E (light vegetable oil)
2) Transparent plastic cups
3) Graduated cylinders
4) Balances
5) Sets of weights
6) Small paper cups that fit on the pans of the balance
7) Permanent markers
8) Ice cubes (make them green by adding food coloring)
9) Additional quart of vegetable oil
10) Paper toweling

Strategy:

1) Introduce the lesson by telling a story about Mr. Dense and Miss Smile (a teacher). Mr. Dense challenged Miss Smile to have one of her students explain and prove to him why his five unnamed liquids reacted in the manner that he described. The challenge must be met before the end of the week, and the student can't read from a paper. The student must show and explain why mixing equal volumes of A, B, and E, produced different results than mixing equal volumes of A, D, E, and B, D, E, and C, D, E.
2) Place the five bottles of liquids on the table in front of the room as you tell the story.
3) Divide the class into teams based on the number of graduated cylinders available.
4) Each team should use the graduated cylinder to calibrate two transparent plastic cups into 20ml, 40ml, and 60ml by pouring 20ml of water from the graduated cylinder into each cup and marking it with a permanent marker. Repeat for the 40ml and 60ml calibrations.
5) Pour 20ml of liquid A, 20ml of liquid B, and 20ml of liquid C into each calibrated cup.
6) Observe, record, and discuss the results, and pour the contents into another unmarked transparent cup.

7) Wash out and dry the calibrated cups with paper toweling.
8) Teams 1 and 2 pour 20ml of A, D, and E into a calibrated cup.
9) Teams 3 and 4 pour 40ml of B, D, and E into a calibrated cup.
10) Teams 5 and 6 pour 60ml of C, D, and E into a calibrated cup.
11) Discuss and record the results. After the students explain what happened introduce the definition for density and place it on the board.
12) Place the balances, sets of weights, and paper cups on the table. Review how to use a balance to obtain the mass of a substance.
13) Each team should find the masses for the three liquids assigned to them in steps 8-10 and calculate the densities.
14) First they obtain the mass for the paper cup. Then they obtain the mass for the cup plus the liquid, and subtract the mass of the cup to obtain the mass of the liquid. Then they use the mass of the liquid and volume to calculate density.
15) Give each team a chart on which to record their data. Record the data on the same chart drawn on the board.
16) Students analyze the data and conclude that D had the greatest density, A, B, and C (all water), were less dense than D, and E was the least dense.
17) Draw a graph on the board to show the relationships discussed. Place mass in grams on the vertical axis and volume in ml on the horizontal axis. Title the graph, Mass-Volume Relationship For Different Liquids.
18) Pour equal volumes of vegetable oil in transparent cups for each group. Place a green ice cube in each cup. Students observe what happens and explain the results. The ice cube will float on the top and form drops as it melts and falls down through the vegetable oil.

Performance Assessment:

1) Students should be challenged to write how they would prove to Mr. Dense that A, B, and C had the same densities, and the densities of D and E were different. E was the least dense.
2) Students should be given the opportunity to present their explanations to the class.

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The Three States Of Matter

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Objectives:

Primary Level

1. Define matter
2. Identify and compare solids, liquids, and gases
3. Identify some properties of matter

Materials:

- -two laundry bags
- -butter
- -sugar
- -milk
- -cocoa
- -vanilla
- -quick oats
- -hot plate
- -cup
- -colored chalk
- -measuring cups
- -flask
- -clear vases
- -variety of solids (toy, tools, school supplies)
- -variety of liquids (water, pop, juice, syrup)
- -variety of gases (big balloons, little balloons)
- -balls
- -salt
- -peanut butter
- -wax paper
- -large plastic rectangular container
- -paper towels
- -spoons
- -measuring spoons
- -cylinder container
- -clear containers to pour liquids in

TABLE 1

Take Up Space	Has Weight	Has Shape of Its Own	Takes Shape of Its Container	Has Definite Volume	Has No Definite Volume
solid	solid	solid		solid	
liquid	liquid		liquid (takes the shape of that part of the container which it fills)	liquid	
gas	gas		gas (takes the shape of the container that holds it)		gas (fills any container in which it is put)

Strategy:

1. Introduce the three states of matter
2. Start with a grab bag. Let everyone take an item out of the bag of solid objects.
3. Describe solid objects and talk about color, shape, size, weight, space, and what is it used for.
4. Fill in Table 1 with the children as you are doing the exercise.
5. Ask the class what is left in the bag after everything is taken out.
6. AIR! pass out objects with air in them, such as balloons, and balls.
7. What is air? It is a gas.
8. Talk about what gas does. Use Table 1.
9. Fill a clear container with water and take a cup stuffed with a paper towel in the bottom. Push the cup straight down in the water.
10. Does the towel get wet? No! Why?
11. What is the water in the container? Liquid.
12. Use Table 1 to discuss what a liquid does.
13. Tell the children that solids, liquids, and gases are the three states of matter.
14. Which one of these couldn't I have an example of and why?
15. Just say, there is another form of matter that we do not talk about much, it is a gas called plasma.
16. Make cookies. Ask how many solids, liquids, and gases are in the recipe.
17. Use a bar graph and chart the information.
18. After you have made the cookies evaluate and see if the children can name all the states of matter.
19. Recipe for the cookies are as follows:

No Bake Cookies

one half cup of butter
two cups of sugar
one half cup of milk
two tablespoons of cocoa
one fourth teaspoon of salt

Bring this to a full boil and remove from the heat. add one half cup of peanut butter while it is still hot, also add one fourth teaspoon vanilla flavor, and three cups of Quick Oats. Use a tablespoon and spoon the cookies onto wax paper.

20. Serve the cookies with juice or milk.

Note* Bring in enough solids for every child to have one.

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Solids, liquids and gases

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Objective:

Using various examples of solids, liquids and gases, the student will be able to define the three states of matter. They will classify the three kinds of matter, describe its properties and give examples of each one. Lastly, they will describe different ways matter can change and will learn related vocabulary.

Materials needed:

1) Liquids (such as: milk, water, oil, honey)
2) Solids (such as: a block, a ball, a sponge, a feather, a brick and a duck)
3) Gases (such as: balloons filled with air and balloons with helium, a garbage bag with dry ice, a flask with a small amount of vinegar and baking soda and a can of soda pop)
4) Mystery box
5) To show matter changing from one form to another:
   (ice cubes, a hot plate, an egg, a pan, candles, mirrors, etc.)
6) To show that air takes up space and has weight:
   (mystery box, clear shoeboxes filled with colored water, balance scale, 4 beakers (250ml), punchball, paper towels, dry ice inside of a garbage bag, Alka Seltzer tablets, water and a balloon, clear plastic cups, sandwich bags, rubber bands)

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Strategy and Activities:

Begin by having the students guess the items in a mystery box. Describe the items in the box. Generalize the specific qualities of each. Do the same for each group of boxed items. Tell what the objects contain. Write the description. Explain that the items with a definite size and shape are solids. Describe the objects with a soft flowing feeling as liquids. Lastly, describe the materials with no definite shape or size as gases. Take examples from each box, tell what specific qualities each has.

To test for air, have each student feel air from a balloon. Second, have students "scoop" air into cups. Place a plastic bag inside and out, feel the air pushing against the bag. Third, place a paper towel inside of a beaker. Put the beaker down into a container of colored water. Decide if the water wet the towel.

Using the model of a molecule chamber, explain that the movement of the molecules represents gases, liquids and solids. Gases move and flow more freely than the others. Its particles constantly strike the walls and bounce off. The molecules of a liquid are packed less closely together than those in a solid. They can move about and we can say a liquid "flows". It takes the shape of a container. A solid's molecules are packed close together and stay in place. A solid has a definite shape.

More discussion will continue as the teacher describes that some liquids become gases when heated. Some solids can become liquids when heated. Gases can become liquids when cooled.

@@

Conclusion:

As the students described the items in each group, they learned more about solids, liquids and gases. They were able to tell why the paper towel did not get wet inside the beaker. They were able to tell what each property was for each item. As a solid, the property was a definite shape. As a liquid, the property is free-flowing. As a gas, the property is more free-flowing and it takes up space.

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Density in Relation to Float and Sink

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Objectives:

(Grades 6-8)

1. To create a density column from household liquid solutions.
2. To calculate the density of an object.
3. To determine why objects will float or sink in relation to density.
4. To predict the density of unknown solutions.
5. To introduce Archimedes' Principle.

Materials:

The following materials are needed for each group of 3-5 students:

- wood (small rectangular or square shape)
- metal screw or nut
- plastic (small rectangular or square shape)
- corn oil
- corn syrup
- food coloring (for water)
- glycerin
- baby bottle or olive jar
- graduated cylinder
- balance scale
- ruler (metric)
- large plastic container or small aquarium
- paper or plastic cups
- small piece of rubber
- aluminum foil

Strategy:

Instructors Preparations and Student Activities:

1. The individual student stations should be set up before students arrive. Put several drops of food coloring into the aquarium. Use different colors for each group with matching cups. (optional)

2. Each station or group will have the unknown household solutions within the cups. Students are given the information in regards to water (density = one gram/cm^3). Pour the unknown solutions into the baby bottle. Students will observe the various columns formed.

3. One should introduce the concept of density using examples and formula, density = mass/volume. Review methods of computing volume. One should include the water displacement method too.

4. Each group should have an object for which to compute the density. For example, a small piece of wood, plastic, metal screw or nut, and rubber should be used to determine the density.

5. After computing the density, students are to predict whether or not the objects will sink or float in regards to density. Water is used as your medium (1 gram/cm^3). Make a graph and place all predictions of the board.

6. After making predictions, students are to drop the objects into the aquarium

to observe whether or not the objects will sink or float. Remove objects from the aquarium and drop the objects into the baby bottles with the unknown solutions.

7. Knowing the densities of the given objects, students are to predict the density of the unknown solutions. Students will make predictions based upon where within the jar the objects floated. For example, did the object float above or below the water? Would the unknown solution's density be higher or lower than that of the density of a known object (wood, plastic, metal, rubber).

8. After making predictions, give students the names and densities of the unknown solutions. Students can compare their predictions. A graph should be constructed in regards to Mass versus Volume.

Supplemental Activities:

To introduce Archimedes' Principle, students will construct a displacement container using a two liter pop bottle. They should cut the top and construct a spout by cutting the side of the bottle 2cm wide and 6cm to 7cm long. Students will discover, when objects are put into the water, the water will rise or be displaced. (Use heavy objects to make observations, for example a can of pop with a known mass.) Archimedes found that the amount of water displaced is equal to the mass of the object.

In addition, Archimedes' Principle can be demonstrated by having students construct a small barge with aluminum foil with measurements about 10 square centimeters. Have students get as many pennies as possible on their barges. Afterwards, one should explain Archimedes' Principle in relation to why ships float.

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Gravity Lesson

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Objective:

This lesson is designed for students in fifth grade, although this lesson can be modified to suit kindergarten through grade 12; even a college level physics course. This lesson can be done within a 60-minute period.

To find out if mass affects the drops of the student-made model parachutes and helicopters.

This lesson incorporates the following Chicago Academic Standards & Frameworks (Science K-6): Conduct experiments and observations and explain what was discovered. Describe conditions that influence change during an investigation. Ask questions and formulate hypotheses. Select and use instruments to collect, organize and present data related to a scientific investigation- timer, stopwatches. Gather data from investigation by applying a variety of scientific skills-measurement and recording methods. Use data based on observations from guided experiments to construct reasonable and accurate explanations. Interpret data and evaluate the accuracy of the outcomes. Compare observations of individual and group results. Use appropriate vocabulary to describe scientific phenomena and instrumentation. Construct simple models that illustrate concepts-a helicopter, a parachute. Compare and contrast an action and reaction in the behavior of objects.

This lesson incorporates the following NCTM- Principles and Standards for School Mathematics: Instructional programs from pre-kindergarten through grade 12 should be able to - Problem Solve; Show Reasoning and Proof; Communicate their thinking coherently and clearly to peers, teachers and others; Create and use representations to organize and record data-graphs, charts, tables, etc.

Materials:

Participation Awards - Super Scientists Awards - Hershey Kisses Treats

Helicopter	**Parachute**
Paper clips	newspaper
Pencils	string
Notebook paper	washers
Scissors+	scissors
Ruler	rulers

Stopwatches
model directions

paper clips
stopwatches
model directions

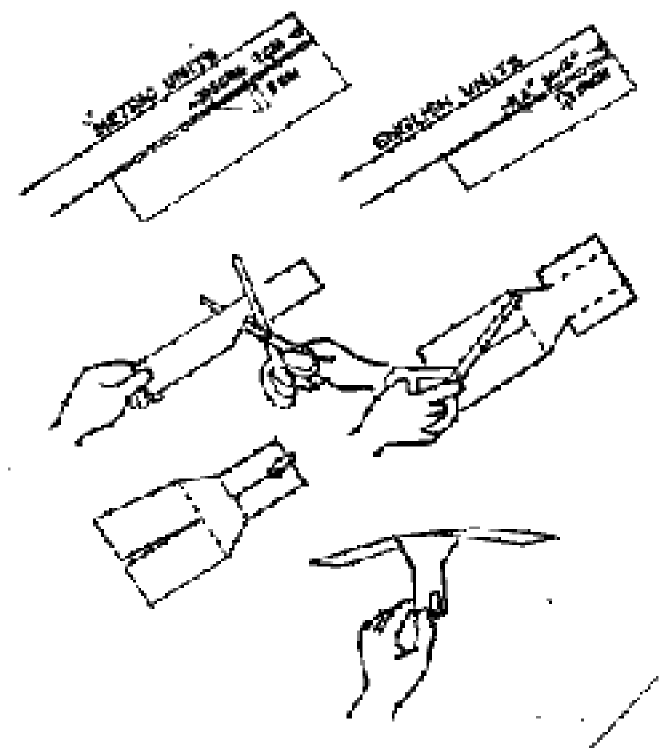
Helicopter Model Directions

· Fold and cut one sheet of paper in half lengthwise.

· Take one of the halves and fold it in half lengthwise.

· Use a ruler to draw a triangle on one edge of the paper.

The base of the triangle will be 1 in. (3 cm) long and one side will be between the 4-in. and 6-in.(9 cm and 14 cm) marks on the ruler. See the diagram:



· Cut out the triangle. Cut through both layers of the paper.

· Open the paper and cut up the center fold to the point indicated on the diagram. This forms the wings.

· Fold the tabs toward the center and attach a paper clip to the bottom.

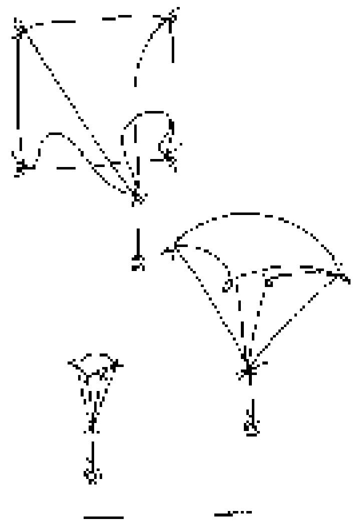
· Fold the wings in opposite directions.

· Hold the helicopter above your head and drop it.

Parachute Model Directions

· Cut a 22 in. (56 cm) by 22 in.(56 cm) square from a newspaper.

- Cut 4 separate strings about 20 in (50 cm) long.
- Tie a string to each corner of the newspaper square.
- Tie the 4 ends of the strings together in a knot. Be sure the strings are all the same length.
- Use a string about 4 in. (10 cm) long to attach the washer to the knot in the parachute strings.



Strategy:

Initiate Motivation: We will begin this lesson by doing the experiments first. The experiments will be done in groups. Four people will be in each group. Within each group there will be: A Retriever; A Recorder; Recorder; A Releaser; A Timer.

Helicopter Activity: 1. Create a helicopter within each group. 2. Pass out helicopter materials to each group. 3. Assign each group to a specific location. 4. Drop helicopters from an agreed height and record time of landing in seconds on notebook paper. 5. Repeat Step 4 with 1 paper clip, 5 paper clips, and 10 paper clips.

Parachute Activity: 1. Create a parachute within each group.   2. Pass out parachute materials to each group. 3. Assign each group to a specific location. 4. Drop parachutes from an agreed height and record time of landing in seconds on notebook paper. 5. Repeat Step 4 with 1 paper clip, 5 paper clips, and 10 paper clips.

Culminating Activity: 1. After students finish their activity and record their data within their groups, all groups should come together as a whole class. 2. Each group should write their data on the board (time in seconds for 1 clip, 5 clips, and 10 clips). Teacher initiates student discussion with the following questions: What happens to the helicopter/parachute as it falls? Why do you think the helicopter/parachute falls to the ground? What was the difference between the helicopter/parachute when it did not have any paper clips and when it had 1 paper clip? What was the difference between 1 paper clip and 5 paper clips? What was the difference between 5 paper clips and 10 paper clips? How do the paper clips affect the landing of the helicopter/parachute? How would you have designed your helicopter/parachute to make it more effective? What do you think your design would accomplish that my helicopter/parachute did not accomplish? Would the new ideas you discovered within your groups change with your new model helicopter/parachute?

Performance Assessment:

The students should be able to perform the criteria set out in the objectives within their groups while creating their model helicopters and parachutes. In addition, students should be able to orally express their findings during the Culminating Activity on an individual basis due to their experience they had within their groups.

Conclusion:

The "Culminating Activity" is the conclusion of this lesson. Pass out Awards accordingly within each group and Hershey Kisses to all students for a job well done.

References:

Board of Education of the city of Chicago, Chicago Academic Standards & Frameworks. United States of America

NCTM, Principles and Standards for School Mathematics.

Vancleave, Janice, Physics For All Kids. John Wiley & Sons, Inc. New York. 1991 (graphics)

Mathematics/Physics

The Great Tin Race

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Objective(s):

Upon completion of this lesson, 6th-8th grade students will be able to:

Describe and recognize motion

Understand what is a reference point

Describe distance in reference to units of measurement

Calculate speed

Calculate average speed

Measure distance

Understand the relationship between distance and time (speed= distance/ time)

Graph data

Use data to make hypotheses

Materials:

- Various sizes of tin cans with the tops and bottoms removed (open ends)
- Two plastic lids per tin can
- Rubber bands
- Paper clips

- Pencils
- Meter sticks
- Measuring tape (inches)
- Masking tape
- Calculators (optional)
- Timers

<u>Strategy</u>:

The strategies devised to carry out my objectives are as follows:

- Lead inquiry discussion about motion concepts

o Defining motion

o Recognizing motion

o Reference point

o Describing distance

o Calculating speed

o Average speed

- Distribute tin racer blueprint sheets, racer data sheets, and speed graphs. (Enlarge one of the speed graphs to record the groups' average speed at 2 m)

- Allow students time to construct tin racers, raceway and complete racer data sheets.

Note: To complete racer data sheets, the following information is needed:

o Distance, time, and speed for three trials

o Average speed

- Have each group place on the chart the data of their racer (distance vs. time).

- Ask students to make predictions based on the group data, i.e. which racer will be the fastest.

- Conduct the tin race (construct a raceway at 3 meters). Record the fastest racers/speed.

- Compare the predictions with the actual results.

- Discuss ways to improve the speed of the racers.

- If time allows, test those improvements, calculate the speed, and record.

Performance Assessment:

Were the students able to follow the blue prints to construct the racers?

Were the students able to measure the distance and time of the racers?

Were the students able to calculate the speed of the racers for each trial?

Were the students able to calculate the average speed at 1 m? At 2 m?

Were the students able to construct motion graphs of their racer's speed?

Were the students able to make predictions based on the group data?

Were the students able to think of ways to improve their racers?

Conclusions:

Through this exercise, students are able to follow directions to construct both the racers and the raceway. Students use measurement skills to conduct the raceway. Timers allow students to approximate the time. Calculating the speed over several trials provides adequate practice of measuring distance, time and calculating speed. The students record data using a chart and line graph. Predictions were made based on the data presented by the group. It does take time for the students to construct racers that are durable and effective. This lesson can be presented in two sessions: the first to construct the racers and the second to calculate the speed, record data, make predictions and conduct the final race.

References:

Kahan, Peter. *Science Explorer: Motion, Forces and Energy*. Prentice Hall: 2000.

The Great Tin Race

Racer Data Sheet

Group Color: ____________________________

Racer's Name: ___________________________

Trial	**Distance**	**Time**	**Speed (Distance/Time)**
1	1 m		
2	1 m		
3	1 m		
Totals			xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
1	2 m		
2	2 m		

3	2 m		
Totals			XXXXXXXXXXXXXXX XXXXXXXXXXXXXXX

Average speed at 1 m= Total distance = ___________________

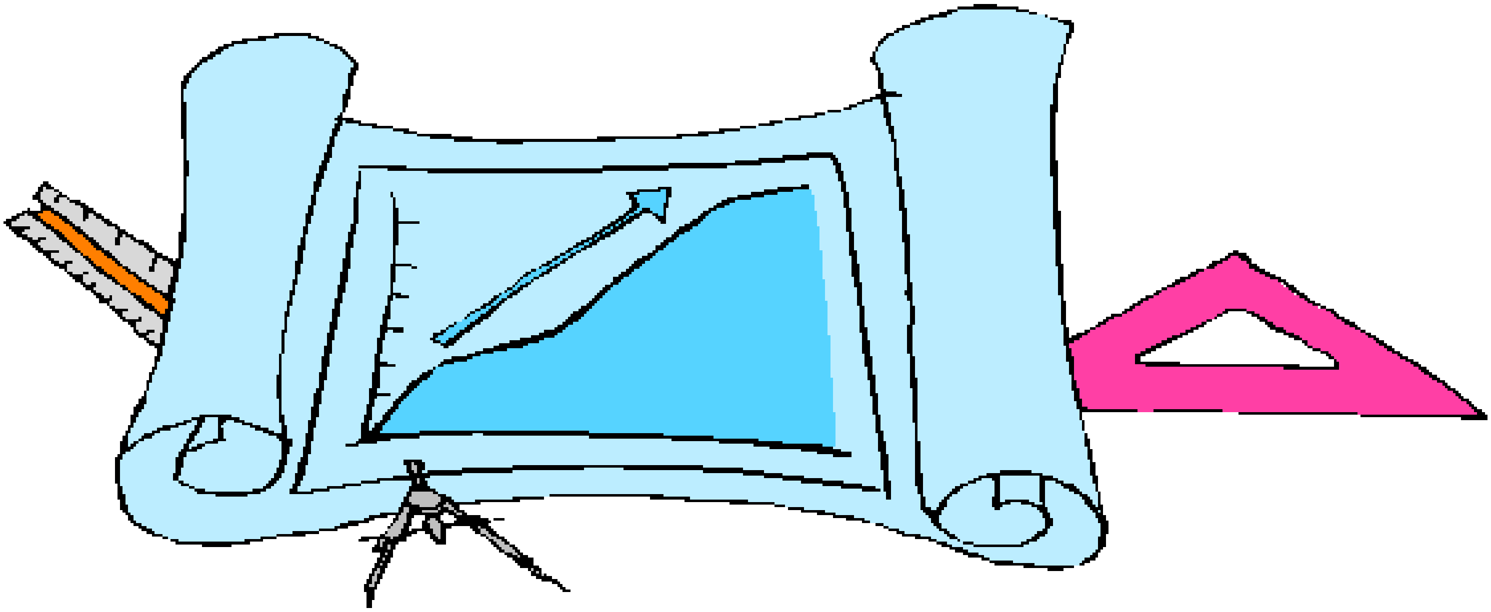
Total time

Average speed at 2 m= Total distance = ___________________ (This data will be recorded

Total time on the large group

chart)

The Tin Can Racer Blueprint



1. Cut off the bottom of an empty coffee can with a can opener.

(This part was done for you! I even filed the metal edges with sandpaper.)

2. Use scissors to punch a hole in the center of both coffee can lids. The holes must be just large enough for a rubber band to pass through.

3. Push one end of a rubber band (a thick one) through one of the holes and hook it around a paper clip on the outside of the lid. Tape the paper clip in place, over the hole, so that the rubber band cannot pull through the hole. Place the lid with the rubber band on the can.

4. Reach into the can and grab the rubber band (be careful of the edges).

5. Push the free end of the rubber band through the hole in the other lid from the inside. Slip the end of the rubber band through a bead so that the bead is on the outside of the lid.

6. Slide a pencil through the part of the rubber band that is on the far end of the bead from the can, so that the pencil stops the rubber band from pulling back through the bead and the lid.

7. Adjust the position of the pencil so that the end of it extends past the edge of the can.

Note: If it is too short, get a longer pencil!

8. Wind up the pencil until it comes back to you freely and put the can on the floor. Let go!

To construct the raceway:

Use masking tape to mark your reference point.

Measure 1 meter from the reference point and use masking tape to mark it. Measure 2 meters from the reference point and use masking tape to mark the end point.

Note: Be sure to record the distance and time traveled on the racer data sheet.

Group ___________________________________

D

I

S

T

A

N

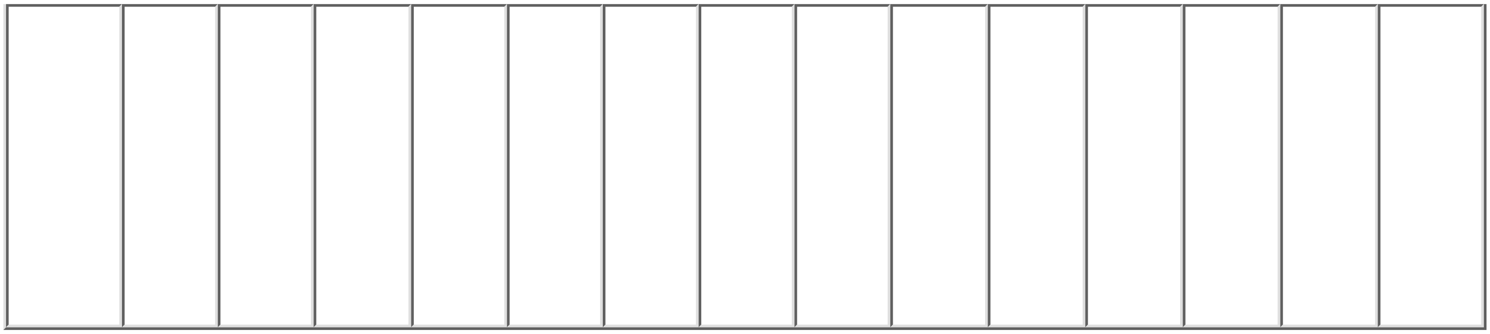
C

E

(m)

Motion Graph

2.5														
2.0														
1.5														
1.0														
0.5														



1 2 3 4 5 6 7 8 9 10 11
12 13 14

Time (sec)

Mathematics/Physics

Center of Gravity

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Objective(s):

Third grade students will be able to find the center of gravity and to define force and gravity.

Materials:

Assorted shapes made of cardboard, yarn, washers; push pins, and a cork bulletin board.

A knife, new pencil sharpened, potato, empty 2-liter soda bottle with cap, and two metal forks of equal size.

Strategy:

Ask the question what is force? A force is a push or pull. The teacher will put the definition on the board. See if you can find the center of gravity of an irregular shape.

1. Cut out the shape from a piece of cardboard.
2. Pin the shape to a bulletin board with yarn and attach a weight at the end of the yarn.
3. Draw a line behind the yarn, pin the shape at several different points and draw a line each Time.
4. The point at which the lines cross is the center of gravity of your shape.

Can you balance the shape from this point on the eraser of a pencil?

Ask the question what is gravity? The teacher will put the definition on the board. Gravity is the force that pulls objects back toward the earth. Gravity is the pulling force between two objects due to their masses.

1. The teacher will cut a 1-inch thick slice from the center of a potato. Push the pencil through the center of the potato.
2. Place the capped bottle on a desk. Try to balance the pencil (on its eraser) on the top of the cap.
3. Stick the two forks into opposite sides of the potato.
4. Now try balancing the pencil (on its eraser) again on top of the soda bottle. Adjust the forks slightly if needed.

What happened? All things have a balance point, or a center of gravity, at which they are in perfect balance. The pencil with the potato is top heavy and will not balance. By adding forks to the potato, you change the center of gravity.

Performance Assessment:

The students should be able to use specific vocabulary to define force and gravity.

The students should be able to find the center of gravity of an object through the demonstration of these experiments.

Conclusions:

Every weight has a center of gravity.

References:

McGraw Hill Science Teacher's Edition, New York, New York, 2000

Taylor, Barbara; Weight and Balance, New York 1990

Mathematics/Physics

The Inertial Balance

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Objective(s):

At the end of this lesson, the student will be able to:

1. Explain how either a single pan or double pan balance operates;
2. Explain the physics principle of the balance using Newton's First and Second Laws;
3. Differentiate between mass and weight;
4. Explain how mass and weights are related using Newton's First and Second Laws;
5. Explain the difference between gravitational and inertial mass.

Materials:

Triple beam balance	Centigram balance
Various masses	Two c-clamps
Metal meter stick or 1m of thin metal flat	Wooden blocks formed into an L shape to hold the meter stick in a horizontal position.
35mm film container to be attached to the end of the meter stick	Masking tape, stop watch

Strategy:

Many students confuse the concepts of mass and weight. Our purpose here is to clarify for the student, through self-discovery, the difference between mass and weight. Further, the student will be challenged to discover how to “weigh” objects in outer space with an inertial balance.

Performance Assessment:

Briefly describe the performance assessment that you would use and the expected results that should be obtained. A grading rubric would also be nice.

-

Background

Weighing, really massing on the surface of a planet or planetoid is easily demonstrated with either a two-pan balance or a centigram balance. Ask students what the balance is measuring (mass or weight). Then start a discussion of how the balance operates. What we ultimately are looking for are the physics principles of the balance. Among these are the fact that gravity is used and that no matter what body we were standing on the balance would operate exactly the same. But what would be different? So just what is the balance measuring- mass or weight? How do we know? So, in order to successfully use either a beam balance or a spring balance we need a gravitational force. These balances are a simple (?) demonstration of Newton's second law. So does the balance measure mass or weight? Why?

What if you were in the orbiting Space Shuttle or space station? Would this balance work? What problems would be present? The measurement of mass presents a unique problem. How do we measure mass in a microgravity environment?

In space, because of the free fall conditions neither a beam or spring balance will operate. So there must be a third method of measuring a mass of an object. This brings us back to Newton's first law. This law is the principle of inertia, the property of matter that resists acceleration. The amount of resistance (laziness) is directly proportional to the mass of the object.

To measure mass in space, scientists use an inertial balance. An inertial balance is a spring device that vibrates the sample being measured. The frequency of the vibration will vary with the mass of the object and the stiffness of the spring. In this case we are using a metal meter stick. For a given spring, an object with greater mass will vibrate more slowly than an object of lesser mass. The object to be measured is placed in the balance, and a spring mechanism starts the vibration. The time needed to complete a given number of cycles is measured, and the mass of the object is calculated.

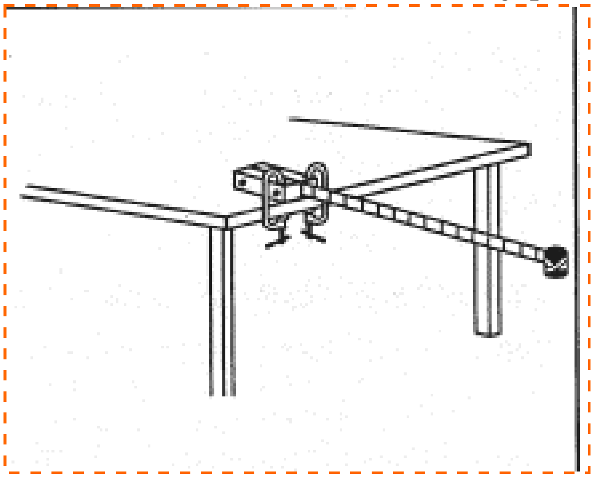
Procedure:

1. Using a drill and bit to make the necessary holes, bolt two blocks of wood to the opposite sides of one end of the metal meter stick.

2. Tape an empty plastic film canister to the free end of the meter stick. Insert a piece of foam into the canister.

3. Anchor the wood block to the table top with C-clamps. The opposite end should swing freely from side to side.

4. Calibrate the inertial balance by placing objects of known mass (pennies) in the sample bucket (canister with foam plug). Begin with just the bucket. Push the end of the meter stick to one side and release it. Using a stopwatch or clock with a second hand, time how long it takes the stick to complete 25 cycles.



5. Make a plot of the data. (See the sample graph.)

6. Place a single penny in the bucket. Use the foam to anchor the penny so that it does not move inside the bucket. Any movement will result in an error (oscillations of the mass can cause a damping effect). Measure the time needed to complete 25 cycles. Plot this data.

7. Repeat this procedure for different number up to 10 pennies.

8. Draw a curve on the graph through the plotted points.

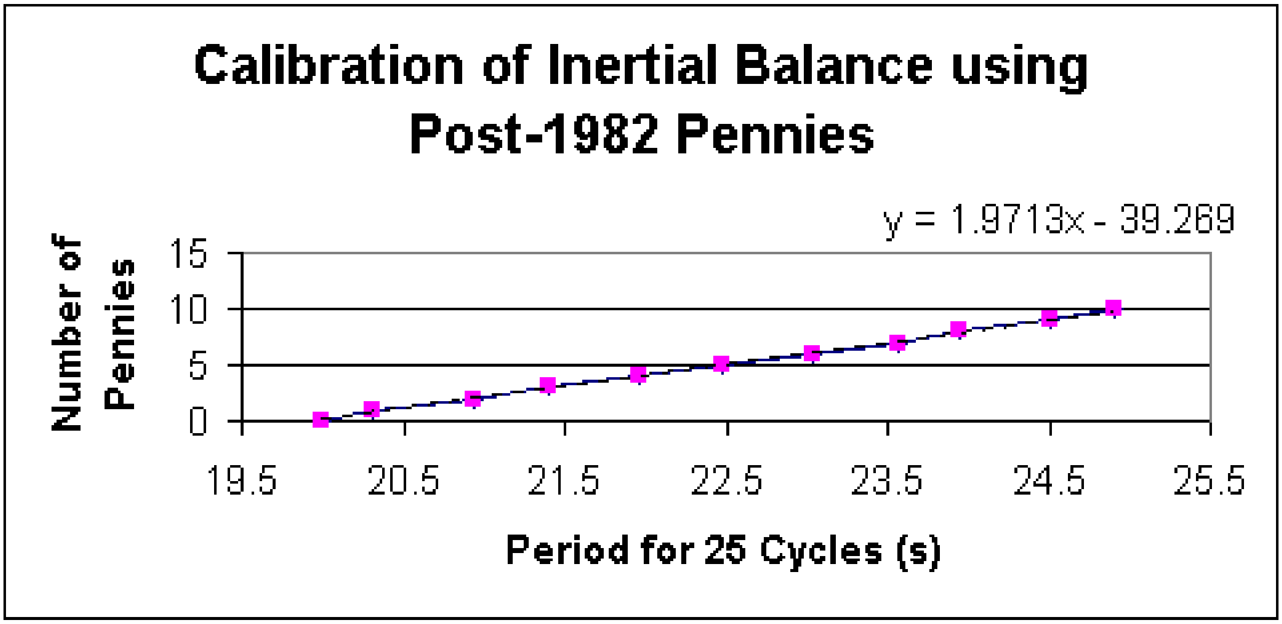
9. Place a nickel in the bucket and measure the time for 25 cycles. Use the pennies plot to determine the mass of the nickel in "penny" units.

-

Conclusions:

25 cycles (s)	Number of Pennies
19.99	0
20.31	1
20.94	2
21.4	3
21.97	4
22.47	5
23.03	6
23.57	7
23.94	8

24.5	9
24.9	10
Quarters	
20.81	1
22.06	2



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Questions

-

1. Does the length of the meter stick make a difference in the results?
2. What are some of the possible sources of error in measuring the cycles?
3. Why is it important to use foam to anchor the pennies in the bucket?
4. Is there a difference between the nickel's inertial mass and its gravitational mass?

References:

Experiment III-3 Inertial and Gravitational Mass Physics: Laboratory Guide, Physical Science Study Committee, D.C. Heath and Company, copyright 1965.

Activity 4 : *Inertial Balance Part 1* Microgravity: a Teacher's Guide with Activities (Secondary Level) National Aeronautics and Space Administration, July, 1992

Mathematics/Physics

Bouncing Balls

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Objectives:

A ball bouncing on a hard surface is used to study the action of gravity on a simple system. We will let a single ball bounce several times, as well as having several different types of balls to bounce off a hard surface.

Materials:

. A supply of several super balls of various shapes and sizes. [They are conveniently available at a local science supply house, or simply order them from **American Science and Surplus** at http://www.sciplus.com.]
B. Several one-meter rulers, and at least one two-meter stick.
C. Several other types of balls; i.e. tennis balls, ping-pong balls, steel balls, wooden balls, rubber balls, and marbles.
D. A **Happy/Unhappy Ball Set** from a local science supply house, or from **American Science and Surplus** at http://www.sciplus.com.

Strategy:

First, take a super ball and drop it from a height of one meter directly over one of the squares in a floor tile, if there is a tiled floor in your classroom. Count the number of times the ball bounces before leaving the square in question, and record the number. Do this several times. Then, drop a super ball of a different size over the square, and record the numbers. Repeat the experiment while dropping from heights of ½ meter and 2 meters, respectively. You should observe that the ball only bounces a few times within the square, no matter how carefully you may drop it. When you drop it from a greater height, it makes fewer bounces inside the square, and more when you drop it from lower height.

Next, divide the class into teams, and have each team to release a super ball at rest from a height h_0 of one meter, and measure the height h_1 to which the ball rises on first bounce. Each team should record its bounce height in a table on the blackboard. Next, measure the height h_2 for the second bounce. Note that

$$\mathbf{h_2 / h_1 = h_1 / h_0.}$$

Bounce the ball from a height of 2 meters, and show that this relation is still valid.

Try bouncing the super ball off a steel plate [if available], and observe that it bounces much higher.

Show that the super ball bounces much better than most other balls, such as ping-pong balls, tennis balls, or ordinary rubber balls. Also, drop the “happy ball, sad ball” set, to show that two balls may appear to be very similar, and yet bounce quite differently.

Finally, drop a little super ball that lies on top of a big super ball. [You may wish to cut out a little trough in the big super ball with a sharp knife.] After the bounce, the big super ball hardly bounces at all, whereas the little super bounces to far above the height of release. Why? See the website given below.

Performance Assessment:

Give each student a super ball, with the objective of having the ball to bounce back and forth, while remaining close to the initial location. It takes a certain amount of practice for you or the student to learn how to do this, and to accomplish it you must give the ball both a spin and an initial horizontal motion. The initial velocity and angular velocity should be opposite in direction, and comparable, for this to work. Each student is given a passing grade when he/she learns to accomplish this task.

Conclusions:

The bouncing ball is used as a tool to illustrate motion, collisions, and behavior of a body in motion**.**

References:

Bouncing Ball JAVA Applet:

http://www.phy.ntnu.edu.tw/java/bouncingBall/bouncingBall.html

You may vary the elasticity of this ball, as it bounces freely across the floor.

Super ball Home Page:

http://www.superballs.com/.

Learn about all aspects of super balls.

Super ball Rocket Launcher:

http://www.physics.gla.ac.uk/gusto/pubsci/exhibits/d12/index.htm

Study of bouncing the big ball with the little ball on top.

Indiana University Demonstrations on super balls [and other things] at the site:

http://www.physics.indiana.edu/~demos/mechdemo.htm.

Several super ball demonstrations are included in this package.

Mathematics/Physics

Mass vs Weight.

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Objective(s):

The purpose of this mini-teach is to give the students an understanding of the concepts of Mass vs

Weight and a basic understanding of metric measurements.

Materials:

The following materials are used in this presentation as hands-on learning tools and demonstration;

Inertial Balance

6-C Clamps

3 Beakers – 1000 ml, 500 ml, 100 ml

Very Large Sponge

Ball of String

6 – Ring Stands

Box of small washers

Small of Beads (or small box of sand)

6-Stop watches

Meter stick

Metric scale

Strategy:

This lesson will start with a brain – storming session concerning the relationship and the previous knowledge of the concepts of Weight & Mass. The class will be motivated to formulate

Ideas about the two concepts to be tested in the class .The second step in this process will to demonstrate the concept of Atoms and Density. The small beads will be used to simulate Atoms of matter in Mass .A class member will be asked to measure the mass of an empty 100 ml beaker and then after it has been filled with the beads. Another student will subtract the masses of the full beaker from that of the empty beaker and divide it into the Mass. This procedure will be repeated for the 500 ml and 1000ml beakers. The class will discuss the findings of the demonstration.

The third step in this unit will to divide the class into groupies of four members. A set of string, 4 washers, Ring stand, Stopwatch, and a meter stick. The group will construct and test a pendulum that has 1 wash for the pendulum bob, string for the pendulum arm. The group will count the number of oscillations made by the pendulum in thirty seconds. This procedure should be repeated by adding one washer at a time and counting the number of oscillations up to four washers.

Performance Assessment:

The students will be expected to draw a graph of their finds of the number of oscillations made by the pendulum in thirty seconds . For the first demonstration the class would be expected to find the densities of all three beaker and compare them. Each student will prepare a paper explaining their views on weight vs mass with references from the internet to support their position .

Conclusions:

The individual students will support their final positions in a paper to be turned in to the instructor.

References:

Density

http://encarta.msn.com/find/Concise.asp?ti=03FD5000

Galileo's Pendulum Experiments

http://es.rice.edu/ES/humsoc/Galileo/Student_Work/Experiment95/galileo_pendulum.html

Gravity Tutorials
http://www.curtin.edu.au/curtin/dept/phys-sci/gravity/index2.htm

Mathematics/Physics

Bouncing Superball Physics

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Objective(s):

1. To explore several striking and unusual properties of bouncing superballs.
2. To measure and understand the elasticity coefficient for a bouncing superball.
3. To understand the role of energy conservation in relation to bouncing balls.

Approximate Level: eighth grade

Materials Needed:

1. A supply of superballs and meter sticks [one per student or one per two students].
2. A collection of balls for bouncing. You may wish to include a ping-pong ball, a tennis ball, a foam ball, a racket ball or squash ball, a rubber ball, a wooden ball, a steel ball, and "happy balls" and "sad balls", and whatever else is conveniently available.

Strategy:

Drop the superball from a measured height $\mathbf{h_0}$ of, say, one meter. The ball will recoil to a height $\mathbf{h_1}$, where $\mathbf{h_1}$ is less than $\mathbf{h_0}$. Let us call the ratio $\mathbf{r = h_1 / h_0}$ the elasticity coefficient of the ball. Drop the ball from several different heights [for example, 0.5 meters, 1.0 meters, 1.5 meters, and 2.0 meters] and measure the bounce heights. You should obtain data somewhat like the following:

$\mathbf{h_0}$ 0.50 meters 1.00 meters 1.50 meters 2.00 meters

$\mathbf{h_1}$ 0.41 meters 0.83 meters 1.24 meters 1.65 meters

When the superball is dropped from a different initial height $\mathbf{H_0}$, it will bounce to a corresponding height $\mathbf{H_1}$, where $\mathbf{r = H_1 / H_0}$ is the same for each bounce. In other words, the coefficient of restitution $\mathbf{r}$ determines the ratio of the "drop height" to the "bounce height" for the superball from the surface in question. The elasticity coefficient represents the fraction of the mechanical energy of the ball that remains after the bounce, the remaining fraction being converted into heat. In principle, both the ball and the table become warmer in this process of bouncing.

If the superball is left to bounce several times in succession, the heights $\mathbf{h_0, h_1, h_2, h_3, h_4, h_5, \ldots}$ become smaller by the same ratio:

$$\mathbf{r = h_1 / h_0 = h_2 / h_1 = h_3 / h_2 = h_4 / h_3 = h_5 / h_4 = \ldots}$$

After ten to twenty bounces, the ball stops bouncing.

Take the box of balls, and drop each ball from a height of 1.00 meters. Note that there is a wide variety of bounce heights, but that balls that have the same constitution actually bounce to a similar height, independently of their size.

Take a small superball and balance it on top of a large superball that is held in your hand. [You may find it helpful to dig a small hole in the larger ball, so that the smaller ball is easily balanced.] Make predictions as to what will happen to the balls when they are dropped onto the floor from your hand. Do the experiment, and observe that the small ball tends to bounce very high, whereas the larger ball hardly recoils at all. In other words, energy is transferred to the second ball from the first one after they strike the floor.

Performance Assessment:

1. At the racetrack with a paramutual betting system, the track keeps about 8% of the wager and returns 92% to the participants. In other words, when you bet $100, on the average you get to keep $92 after the first bet. How many times must you bet before your holdings are down to $1? Write an essay on why you should never, never bet at the races.
2. Can you make a superball bounce back and forth about a central location. You should release the ball from a given height with both a spin and a horizontal speed. Practice until you learn to do this with agility.
3. Try throwing a superball off a smooth horizontal surface and then under a table. Notice that the superball will typically come right back to you, boomerang style. Try to explain why this occurs.

Multi-cultural Comment:

Students and teachers of physics have wondered long long and often what would happen if a superball were dropped from the top of a high building, such as the **Sears Tower of Chicago.** That building, with a height of **440 meters** above ground level, has recently lost the designation of world's tallest building to a new structure in **Kuala Lumpur, Malaysia** on a ridiculous technicality. Fortunately, the fate of the superball can now be known, as a result of experiments done by resourceful team of Australian researchers at a radio antenna tower of comparable height. When they dropped the superball onto the pavement below, the ball shattered into glasslike slivers, which were propelled at great speeds from the impact point. One of the experimenters narrowly escaped injury from the shattered fragments. Alas, it seems that the superball has limited superpower.

References:

Jearl M Walker, The Flying Circus of Physics. This reference contains a variety of applications of superball physics.

Porter Johnson - Illinois Institute of Technology

Superball Physics

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Objective(s):

This lesson is suitable for an 8th grade student. To study the motion of superballs in the air, colliding with and bouncing off smooth surfaces. Basic features of moving and colliding objects can be demonstrated and studied using this familiar and fascinating toy.

Materials Needed:

A supply of superballs of various sizes and colors for use by students in teams of two. A supply of meter sticks [with some two meter sticks] is needed for each set-up.

For the initial demonstration of bouncing you will need a supply of various types of balls, some of which bounce very well, some poorly, and some not at all. In particular, you should get a **happy ball sad ball** set [available at toy stores everywhere].

Strategy:

Begin by bouncing superballs and showing that their bounce is quite "springy" or "elastic". Show that the smaller superballs bounce just as well as the big ones. Show that superballs bounce better than tennis balls, ping-pong balls, and golf balls.

Show the "happy and sad balls", and ask the group to predict how they will bounce. In particular, have the class discover that the "sad ball" feels a lot like a superball, so that it might bounce rather well. Unfortunately, it does not bounce at all, even though the result is not obvious from handling it.

Practice dropping the ball in front of the class, showing how to release the ball from rest, measuring the height of the **bottom** of the ball above the floor. Also, show how to measure the bounce height, again defined as the maximum height of the bottom of the ball above the floor on first bounce. Divide the class into groups of two, and have them each drop a superball from a height of 100 cm [one meter], and record the bounce heights on the board. Here is a set of typical bounce heights [in cm], arranged in increasing order:

72 76 78 79 80 80 80 81 82 83 85

Note that there are eleven independent measurements on the list, and that the median height is 80 cm, with seven of the eleven measurements lying between

77 and 83 cm. Thus, an "eye-ball" estimate of the measured bounce heights is **(80 ± 03) cm**.

<-------------- RANGE -------------->

72 76 78 79 80 **80** 80 81 82 83 85

MEDIAN

If your students are sufficiently advanced or "calculator literate", you should show them how to compute the mean and standard deviation of these numbers;

The **elasticity coefficient r**, which we define as the ratio of the bounce height to
the initial height, is roughly independent of bounce height, as the class can demonstrate by studying the dropping the ball from initial heights of 50 cm and 200 cm.

Have the class drop the ball from an initial height of 100 cm and measure the maximum heights for second bounce. The data [in cm] may look something like this:

56 58 59 60 63 64 64 66 68 69 72

By "eyeballing" the data, we estimate the measured heights on second bounce to be about **(64 ± 6) cm**. Note that, for two
bounces, the ratio of
second
bounce height to initial height is about $r \times r = r^2$. Correspondingly, for three bounces the ratio would be about $r \times r \times r = r^3$. One can count **10 - 20** independent bounces for the ball, each of lesser amplitude, before the ball seems to stop on the floor.

One can summarize by saying that on each bounce, the ball returns to $r = 0.80$ of its initial height, corresponding to the fact that the fraction $1. - r = 0.20$ of the initial energy is dissipated upon collision with the floor.

Impress upon the class that, because the ball loses some mechanical energy after each bounce, it can **never**, **never** bounce higher than the initial release height, and get them to agree with this basic consequence of energy conservation. Having thoroughly convinced them of this point, take out a smaller super ball and put it into a small indentation in the bigger ball. Hold the bigger ball in your hand, with the smaller one sitting on top of it, and carefully drop it. Repeat the exercise several times, and observe that, under optimal conditions, the smaller ball goes several times higher than its initial drop height. The smaller ball is, in effect, drawing energy from the larger ball, so that is can go much higher than otherwise. [The **Jupiter slingshot** maneuver, in which a satellite can increase its speed by doing a "hairpin" loop around a major planet, which is used to extend the range of inter-planetary rockets, operates because of similar principles.

Performance Assessment:

A superball can be made to bounce several times near its initial location, but it will eventually bounce away because of mis-alignments, imperfections, etc. Can you make a superball bounce back and forth about a given location. This is a skill which each class member can acquire, simply by bouncing the ball on the floor, trying various schemes, and the like. The trick is to release the ball with an initial horizontal velocity and spin. By picking the right initial conditions, the ball can be made to bounce back and forth.

Conclusions:

The vigorous bouncing of the superball is an useful vehicle for illustrating and studying the basic concepts of energy conservation, energy transfer, and dissipation of mechanical energy as heat.

Multi-cultural Component:

In various types of sponsored gambling, whether legal or illegal, the "house" gets to keep a certain percentage **p** of the total amount of the wagers. In other words, the total amount paid to the winners is the fraction $r = 1. - p$, multiplied by the total amount of the wagers. The fraction paid back after two bets [just like two bounces of the ball] is r^2, after three bets it is r^3, etc. Eventually, or course, the "house" ends up with all the money, for the same reason that the balls stop bouncing. Urge your students to keep these points in mind when they think of placing bets. If they persist in gambling, they might wish to learn about the super ball lottery:

http://www.super-ball.com

References:

A web-based reference on bouncing baseballs is given at the following site:

http://www.exploratorium.edu/baseball/bouncing_balls.html

This site, developed by the Exploratorium [an excellent interactive science museum in San Francisco], outlines experiments with baseballs, tennis balls, and golf balls, and in particular the temperature dependence of the bounce.

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Earl Zwicker - Illinois Institute of Technology

The Jensen Bar - What is it and How to Make One (See Sketch and Photo Below)

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Objectives:

1. To make a Jensen Bar
2. To learn where to get the materials
3. To learn how to put them together to make a Jensen Bar
4. To learn how to "fine tune" the Jensen bar

Materials Needed:

1. A "one-by-two" inch wood board
   .. at least 4 feet long
   .. pretty much free of knots
   .. pine is easy to work with

   Buy at a local lumber yard (Home Depot, Menards, Builder's Square, etc) Often found in a 10 ft length, so two 4 foot Jensen Bars may be made from it. You may also make "weights" from this board.

2. Cup hooks and eye hooks

   Packages of 1/2 inch brass cup hooks may be found at the local hardware (True Value, Ace, etc). You will need 20. You also will need 10 screw eyes (size 214 1/2 is ok), available at the same stores.

3. Metal rod

   At the local hardware store, buy a smooth metal rod. A 1/4 inch diameter curtain rod will do. Length is not critical, but should be about 12 to 20 inches long.

3. Tools & Supplies

   hand saw

   ruler (British units or metric, your preference. A meter stick usually has both.)
   drill & 3/8 inch bit
   sandpaper
   pencil
   scratch awl or push pin
   carpenter's square

   These items may be found in your school shop, if you have one.

(It pays to be on good terms with your shop teacher!) Seek help if you feel the need, from a colleague, another school, university or industry if you feel the need.)

Strategy:

In General -

The ruler, pencil and square should be used to locate the various points on the bar where you will make holes for installing hooks, etc.

Look at the drawings and picture of the Jensen Bar shown below. This will give you an idea of how your finished bar should look.

The instructions that follow are probably more detailed than you need if you have experience at making things.

1. Making the bar

   With the aid of the ruler, pencil, saw and square, cut the one-by-two to a length of exactly 1.10 meters (or 40 inches if you prefer British). Sand rough ends and corners smooth. You now have a "bar" of wood.

   Either of the 1.10 meter by 2 inch faces of the bar will be called the "2 inch face." One of the 1.10 meter by 1 inch faces will be called the "bottom edge" of the bar. The other will be called the "top edge."

2. Making the center hole

   Push the point of the push pin (or scratch awl) into the bar at the exact center of its 2 inch face, and remove, leaving a small hole. Use the small hole as a guide and drill a hole through the bar (about 3/8 inch diameter) perpendicular to the 2 inch face. A drill press can help ensure perpendicularity. Sand hole edges smooth.

3. Making a "20 cm" hole

   Arbitrarily identify one of the 2 inch faces as the "front" of the bar. Following a procedure similar to #2 above, drill a 3/8 inch hole with its center located exactly 20 cm (or 8.0 inches if using British) to the right of the center hole.

4. The cup hooks

   The idea is to end up with a set of cup hooks along the bottom edge of the bar, spaced exactly 10 cm apart. (Use 4.0 inch spacing for British.) You will also want a cup hook on the top edge of the bar, centered exactly above the 3/8 inch center hole.

   At the exact center of the bottom edge, make a small hole (push pin). It should be directly below and perpendicular to the 3/8 inch center hole. This is where you later will screw in the center cup hook. Do the same at the exact center of the top edge to put (later) a cup hook there.

   On the bottom edge, make 8 more small holes, 4 on each side of the small hole you just made at the center, and space them exactly 10 cm apart (4.0 inch for British).

Carefully screw the cup hooks into the small holes on bottom edge, perpendicular to the edge. If you can, use your fingers to do this, since this will probably give you the best control.

You should now have 9 cup hooks installed on the bottom edge: 1 at the center and 4 on each side. Install a cup hook at the top center also.

You now have a Jensen Bar!

5. Weights

   It is useful to have a set of identical weights that can be hung from the cup hooks, and attached to each other from below, in tandem. A set of such weights can be made from the same "one-by-two" board.

   Cut 10 pieces from the board, each 8.0 cm (3.0 inch British) long. Lightly sand corners and edges. Hold one of the pieces with its 8.0 cm dimension vertical. Use the push pin to make a hole at the center of its top end. Do the same for the bottom end. Then put a screw eye into its top end, and cup hook into its bottom end. Repeat for the other 9 pieces.

   These are the weights.

6. Fine tuning

   Suspend the Jensen Bar from the cup hook at its top center. (This may be done any convenient way: use a 1/8 inch diameter rod clamped to hang over the edge of a table; clamp a board to a table top so that it protrudes out over the edge of the table and mount a screw eye on that end; use a ring stand with a 1/8 inch rod clamped horizontally, etc.)

   The bar should hang so that it balances horizontally. This usually doesn't happen because of uneven density of the wood and/or because of the weight of wood removed by drilling the 20 cm hole.

   In order to make it balance horizontally, weight must be added to the end of the bar that moves up. Find some small nails and lay one at a time at that end, until the bar is balanced horizontally. Then drive the nails into the end of the bar, taking care not to damage the cup hooks.

   It should balance nicely in a horizontal position, and your Jensen Bar is now "fine tuned."

   It is also useful to use a broad-tipped marker pen to place numbers on the front face of the bar. Place a "0" at the center. To the right of center, place a "1" at the 10 cm cup holder position, a "2" at the 20 cm position, etc. Similarly, use a different color marker to number successive 10 cm cup holder positions to the left of "0."

Assessment:

This assessment has two objectives:

a) To test the Jensen Bar to see that it works well enough for classroom use.

b) To provide the beginnings of insight into how it may be used, for teachers who do not usually teach the physical science ideas associated with the Jensen Bar. You will assess your own understanding, and so will learn what questions to ask to get help.

With the Jensen Bar suspended horizontally, hook a weight to the cup holder at position 2. What happens? Is this what you expected?

At what position must you hang a second weight in order to bring the bar back to horizontal?

If two weights are hung (in tandem) at position 2, what happens? Is there a position that a single weight now may be hung to bring the bar back to horizontal? What do you think it is? Does it work?

Can you formulate some simple rules that will correctly predict where and how much weight must be used to bring the bar back to horizontal from an unbalanced position?

What happens if the Jensen Bar is suspended by placing it on a horizontal rod through its center hole? Move the bar to a non-horizontal position and release it. What happens? Try other non-horizontal positions. What happens? Can you explain this?

Conclusions:

We state without proof at this point, that the Jensen Bar may be used from kindergarten through PhD to pose challenging problems in mechanical equilibrium to the learner.

This may be the basis for future "lessons" using the Jensen Bar, to appear on this website.

References:

Find a physical science book and look up "levers."

Find a physics teacher who is willing to explain.

A sketch of the bar and weights.

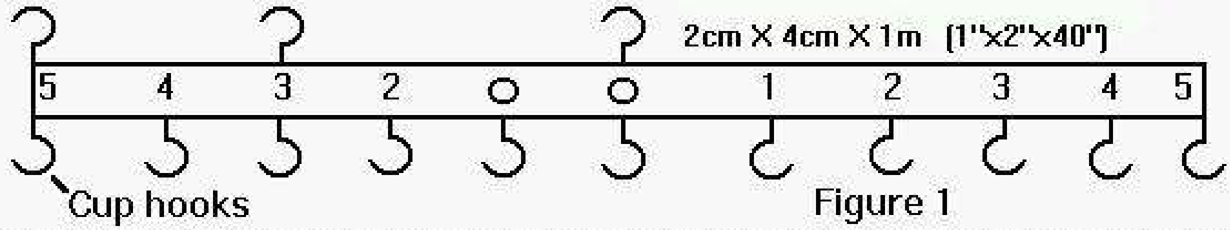

Figure 1

Jensen Bar supported through the center hole

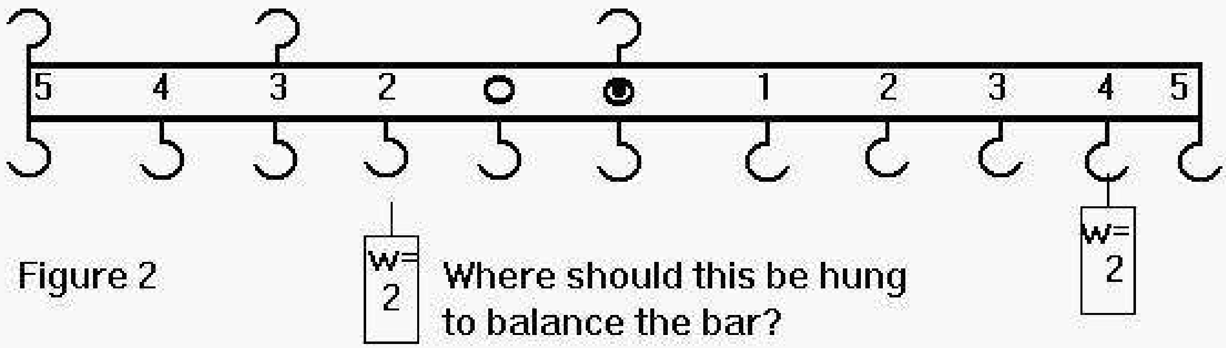

Figure 2

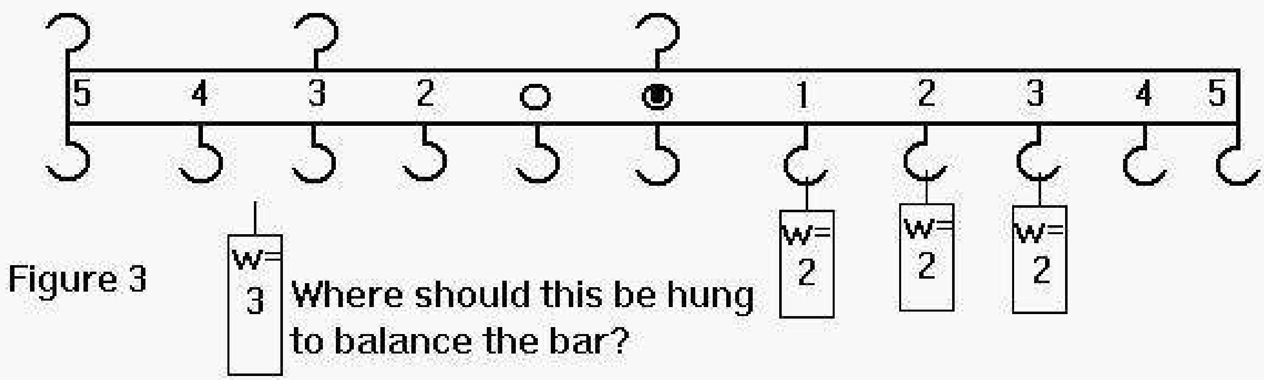

Figure 3

A class set of the Jensen Bars

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Richard J. Watson - Orr High School

Linear Motion: Speed, Velocity & Acceleration

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Objectives:

This lesson is designed for high school and is adaptable to lower levels.
Students will be able to measure linear distance and time and calculate velocity.
Students will be able to plot graphs to show: speed vs distance; velocity vs distance

Materials Needed:

2 meter sticks per group of 6 students
2 stop watches or watches with second hands per group
1 Pencil and data sheet per group

Strategy 1:

Group students in groups of six:

- 2 students - Using meter sticks in a leap frog manner students will measure distance of 100 meters from teacher designated spot.
- 1 student - Stand at the starting position (designated by teacher) and indicate the vehicle being timed by yelling "GO", or waving arms or flag, as it crosses the designated position.
- 1 student - Stand at the finish position (100m from start) and indicate the end of timing by yelling "STOP", or waving arms or flag as the vehicle crosses the finish position.
- 1 student - Stand, with a stop watch or watch with a second hand, in view of the student indicating the beginning and the student indicating the ending of timing.
  At the "GO" command the student starts timing and at the "STOP" command student ends timing.
- 1 student - Record the time and direction of each vehicle on the data sheet.
  Obtain data from each of the other groups.
- Each group - Collect data for at least 3 vehicles

Strategy 2:

5 students stand at the following positions, one student at each position:

- Start position - indicate the vehicle being timed by yelling "GO", waving arm or flag as it crosses the start position.
- 25 meters position - begin timing at the "Start" command and stop timing as vehicle crosses the 25 meter position.
- 50 meters position - begin timing at the "start" command and stop as the vehicle crosses the 50 meter position.
- 75 meters position - begin timing at the "start" command and stop as the vehicle crosses the 75 meters position.

100 meters position - begin timing at the "start" command and stop as the vehicle crosses the finish line (100 position).

Performance Assessment:

1. Student will calculate the average speed and the average velocity for each group using the following formuli:

   speed = distance/time   velocity = distance & direction/time

2. Student will plot on a graph velocity vs time and speed vs time.

3. Students will measure the time of a vehicle at 5 five distances from "0" to 100 meters and plot the acceleration of the vehicle on a graph.

Conclusions:

1. Students learned the difference between speed and velocity by measuring distances and times and using formuli to calculate speed and velocity.
2. Students learned how to use data from a table to plot a graph showing the information.
3. Students learned that motion is defined in relative terms.
4. Students learned that acceleration is a rate of change in speed or velocity (increase or decrease).

References:

Hewitt, Paul, **Conceptual Physics**, Scott Foreman Addison Wesley, 1999
pp 10-15

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Wanda Pitts - Douglas Academy

Energy

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Objective(s):

The students in third grade will be able to describe and compare how energy in different forms affects common objects and is involved in common events. Define kinetic and potential energy.

Materials Needed:

A hammer, nails, wood, ice cube, bat, ball, nerf ball and a basketball net, matches, rubber bands and a slinky.

Strategy:

What is energy? The teacher will put the definitions on the board. Kinetic energy is the energy an object possesses because of its motion. Potential energy is the energy an object possesses because of its position (or state of strain). An example is a bow when ready to shoot an arrow. Model examples for students then let students repeat what was demonstrated to the class.

Performance Assessment:

Examples:
A ball thrown vertically upward leaves the hand with a certain speed and a corresponding amount of kinetic energy. This kinetic energy is completely converted to gravitational potential energy as the ball rises and comes to a stop at its highest point. Then as the ball falls back to earth, its potential energy is gradually changed back again to kinetic energy. Since the ball returns to the level from which it started with the same speed with which it left the hand, it has exactly as much kinetic energy at the end of its flight as it had at the beginning. Although its energy changed from kinetic to potential and back to kinetic again, none of its initial energy was lost. Take a rubber band and stretch it. What kind of energy can a rubber band produce? It takes energy to pull the rubber band in turn this is potential energy.
Take a hammer, a nail and a block of wood, hit the nail into the wood with the hammer. What kind of energy was used?
Hit a ball with a bat. What kind of energy is used?
Kinetic to kinetic, kinetic to potential conversion.
Make a slinky walk down the stairs. What kind of energy is used?
Shoot a ball into a basketball hoop. What kind of energy is used?

Look around the classroom, what sources of energy can you find?
A light switch - potential energy

Which has more energy a ice cube or a lit match?
Hold a lit match in one hand and hold a ice cube in the other hand.
The ice has more mass therefore, it has more potential energy.

If you plug in a fan, what kind of energy is produced?
Kinetic energy (motion)
Can the fan produce energy without being plugged in? Yes, you can turn the blade with your hand.

The students will write their results from the various activities. This writing assignment will give some practice for the IGAP writing test.

Conclusion:

The students should be able to define kinetic and potential energy.
The students should be able to identify when kinetic and potential energy is used in their everyday lives.

References:

What If? Mind Boggling Science Questions for Kids page 37 Robert Ehrlich 1998

Science Explained - The World of Science In Everyday Life A Henry Holt Reference Book 1993

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Camille Gales - Edward Coles Elementary School

Potential Energy: How is It Related to Kinetic Energy?

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Objective(s):

This is an integrated primary level math and science experience designed to demonstrate the relationship between potential energy and kinetic energy. The greater the input of potential energy (altitude of the ramp), greater the output of kinetic energy (distance traveled). The steeper the ramp the greater the distance an object will travel (roll).

Materials Needed:

matchbox toy cars, a ramp with an altitude of 3 centimeters and a length of 28 centimeters, a ramp with an altitude of 6 centimeters and a length of 28 centimeters, a ramp with an altitude of 12 centimeters and a length of 28 centimeters, masking tape, a smooth flat surface, centimeter tapes or meter sticks

Strategy:

Place the ramps on the floor or other smooth flat surface. Place the tapes or meter sticks at the end of the ramps. Place each car at the top of the ramp and release it. Measure the distance the car travels. Do three trials for each of the three ramps. Record the results.

Performance Assessment:

Primary level children: develop a chart that shows each trial run for the car (a column for ramp height beside the column for distance traveled), develop a bar graph for each ramp to display the results, explain the relationship between the altitude of the ramp and the distance traveled by the car, accurately state that the unit of measure being used is centimeters.

Intermediate and upper level children: average the results of the three trials, interpret the results in terms of the relationship between the slope of the angle of the ramps and the distance traveled, develop charts and graphs to organize and display the data

Conclusions:

The cars released from the ramp with the altitude of 12 centimeters should travel the greatest distance. When the altitude of the ramp is doubled the distance traveled should also double demonstrating that there is a direct relationship between the altitude of the ramp (potential energy) and distance traveled (kinetic energy).

References:
Physics:Its Methods and Meaning. Alexander Taffel. Allyn and Bacon, 1986.
Primary Science Curriculum Guide Chicago Board of Education, 1979.

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Mathematics/Physics

Mass/Acceleration

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Objective(s):

To see the relationship between mass and acceleration of an object.

Materials Needed:

(8 groups of 3)…………8 pairs of scissors 8 spring carts

1 roll of masking tape 8 metersticks

8 sheets of plain paper 8 pencils

16 masses of 1 kg

Strategy:

Students will work in groups of three. In the group, one will be the starter, one will be the spotter, and one will be the recorder. The recorder will make a data chart as follows:

	Distance Cart Moved	Distance Cart Moved With 1 Mass	Distance Cart Moved With 2 Masses	Conclusions
Trial l Trial 2 Trial 3 Trial 4				

1. The starter should label the number or name of his/her group with masking tape and place it on the spring
2. Locate each group in a marked area against the wall.
3. Starter should release the cart without pushing in spring (force) and observe.
4. Starter should push spring (force) in half way, by forcing against the wall, and release. Then record observation.
5. Starter should push spring in all the way, by forcing against the wall all the way, and release. Then record observations and data on data chart.
6. Repeat #5 using 1 mass (1 kg) on the cart, and record on data chart.
7. Repeat #5 using 2 masses (2 – 1 kg) on the cart, and record on data chart.

Performance Assessment:

Rubric:

5 A. Explanation on paper shows understanding that force produces acceleration.

B. Explanation on paper shows the more mass the less distance the cart will travel.

C. Data chart information all recorded.

4 A. Explanation on paper shows the more mass the less distance the cart will travel.

B. Data chart information all recorded.

3 All information on data chart recorded.

2 About half of the information on data chart recorded.

1 No information recorded at all.

References:

Science Connections……….Merrill

Mathematics/Physics

"**It's So Simple**"

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Jacques Marquette Branch
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Objective(s):

- This lesson may be used as an introduction to Simple Machines. It may be applied to various grade levels.
- Students will receive a visual explanation of how machines we see in everyday life work.
- Students will also learn the need for these machines and why we must use them in our everyday life.

Materials Needed:

Include each of the following activities in a separate medium-sized container.

Activity 1. Two sticks of modeling colored clay, plastic ruler, beans (pinto or lima).

Activity 2. One stick of colored clay, two large spools of thread (one without thread), a dowel (cut into two parts - one 4 inches and the other 10 inches), string (10 cm) and Hershey Nugget candy in gold wrappers.

Activity 3. Two medium-sized plastic solo cups, one sheet of laser copy paper (8.5 x 11), six balls of lemon drop hard candies and one stick of colored clay.

Activity 4. A small cardboard box, seven paper fasteners, an 8cm rectangular cardboard strip, 2-5cm cardboard strips, 4-3cm circular pieces of cardboard, glue, one-hole puncher and Hershey Nugget candy in gold wrappers.

Strategies:

Brainstorming, Guided Instruction. Cooperative Grouping and Discovery Learning

Before all activities begin, students should be given an imaginary scenario (on a 4x6 index card about different families. Their task will be to help the family solve their problem using only the supplies in their science boxes.

The following is the story for Activity #1:

> The Wee Davis family is rich. They have lots and lots of gold. One problem they have had lately is trying to fight off the Giants who come out of Monster Lake. The Wee Davis family is nice and would like to share their gold, but the monsters are mean and want to take all of the gold for themselves. Can you help The Wee Davis family fight back against the giants when they attack?

Teacher's Solution:

Students must use the materials for activity 1 to discover how to make a lever that will fire beans back at the giants.

Teacher must allow discovery time and guide students to eventually place the ruler over one stick of clay (like a seesaw). Place a bean on one end of the ruler and create a person (using the clay) to jump on the raised end of the ruler to fire the beans at the giants.

Story for Activity #2

The Wee Jones family is planning to take a vacation. However, they are afraid that if they leave home, the giants will steal their bars of gold. The family would like to pick up their bars of gold and put them in the car to take them on the trip, but they are simply too heavy.

Can you help the Wee Jones family find a way to put the bars of gold in their car without using their bare hands?

Teacher's Solution:

Students must discover how to create a pulley (using the materials given) to lift the gold nuggets.

First, glue the two dowels together to create a 90 degree angle (an upside down L). Place the unthreaded spool on the dowel suspended in the air. Place the longest dowel in the center of the spool of thread to make the pulley stand by itself. Next, place the thread, in one wrap, over the top of the suspended spool making a pulley. Tie one end of string in a knot around a Hershey Nugget and allow one of the clay people to pull the other end of the string.

Story for Activity #3

The Wee Adams family always seems to have a problem with the monsters of Monster Lake when they are trying to take gold from one side to the other. The monsters always steal some of their gold. The Wee Adams family is fed up and needs your help. Can you help the Wee Adams family get from one side of the lake to the other without having to walk in the water and risk losing their gold?

Teacher's Solution:

In this activity, students must discover how to make an inclined plane.

Place the mouths of both Solo cups face down and spread apart. Fanfold the laser paper on the 11inch side (make 4 folds on both 11 inch sides). Place the fan-folded paper on the solo cups and slide your lemon drops from one side of the bridge to the other using the clay family you've constructed.

Story for Activity #4

The Wee Brown family just received word that a sick cousin must have an operation right away. He keeps getting bigger and bigger. The doctors say that he needs 12 bars of gold to cover the cost of the operation. The Wee Brown family will have to send the gold from their safe, but it will take hours or maybe days for them to unload 12 bars from their safe. They may also have to take breaks to regain strength while unloading. Can you help them find an easier and faster way to put their gold into the car and drive to the hospital before their poor cousin explodes.

Teacher Solution:

In this activity, students must discover how to make a bulldozer (lever) with the parts given or make a dolly (wheel and axle). Punch a hole in the center of each wheel and four holes in your box to make a place for the wheels. Use fasteners to lock them in place. Connect two - 4 cm rectangular strips to one end of the box and glue a vertical cardboard strip to each of those pieces. Connect another 4cm strip to just above the rear passenger wheel. Connect the longest strip (8 cm), using fasteners, to this strip (this part will be your lever). Now you can place the gold nuggets on your lift and pick up each piece to help the family get to the hospital. (Please call for further explanation if needed).

The second solution would be to have students create a wheel and axle (dolly).

Performance Assessment:

Teachers may assess student's performance visually. Instructors may also develop a rubric based on how close students come to the teacher solutions given. Students who do not develop a simple machine are obviously not using their background knowledge and should be graded accordingly. Those students whose creations exceed the teacher solutions should obviously be graded higher.

References:

None

Mathematics /Physics

The Soup Roll

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Objective:

This lesson is designed for Grade 5.

Students will be able to determine if the contents of a can affect how long it takes to roll down an incline.

Materials Needed:

3 6 x 1' ft. slantboards

3 cans each of a creamy soup, a broth and a chunky 10 ¾ ounce soup cans

3 cooperative learning groups which elect a leader, roller and time keeper.

clock with a second hand

1 worksheet per group

3 yardsticks

2 inertia rods

(2 yardsticks with weights attached)

Strategy:

Students will be divided up into groups. Each group will get a can of each type of soup, a stopwatch, a work sheet and a slantboard. Students will roll each can 3 times down the slantboard and record the time from the top of the inclined plane to the very bottom where a yardstick will be placed. Each group will do this three times and average the results. Students will record their times on their worksheets. Do the same thing on a smooth, flat surface, such as the table top or the floor. Is there a difference in your results? Conclude whether a different type of soup rolls faster or slower and explain why.

Students will then try and roll two can down the slantboard at the same time. Students will time the soups to see which moves faster. They will record their findings. Students will be asked to explain why they think one can rolled faster than the other. Students should conclude the heavier can moves slower because of its weight and contents.

A final exercise that could be tried with the entire class is to have class compare to weighted inertia rods. Two students are ask to lift an inertia rod in one hand, with that hand extended. Each student must hold the rod vertically; twisting the inertia rod back and forth with the arm as an axis of rotation. Have two more pupils count how many times the pupils twist the rods. Have the pupils exchange inertia rods, and do the exercise again. The class is the audience. Pose the question to the class **"why do you think one person was able to move they're inertia rod faster?"** The students should be able after exchanging rods to determine that the weights of the two inertia rods are equal, but the weight is distributed differently in each of the rods. The class must explain why one pupil can twist his rod faster than the other pupil. Their explanation must correspond with the explanation of why one type of soup can rolls faster than the others due to the differing weight factors.

Performance Assessment:

Students will be assessed based on their participation. The teacher will observe and pass by each station and ask each student why they feel this phenomena is happening. All students should be able to tell what they saw happening.

Straight Line Motion in Two Parts

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Objectives:

Students will observe both constant and accelerated (changing) motion. They should be able to calculate speed from distance and time measurements. They will graph distance vs time for each motion and observe that the two motions look different when graphed. This was designed for upper middle school to 9th grade students.

Materials Needed:

Per group of 2 or 3 students:

Stomper (battery powered toy car)
Stopwatch, or second hand on a clock
Meter Stick
Toy car, not powered
A long slope (a table with two legs propped up with some books)

Strategy:

Part I: Stomper

Issue a Stomper, stopwatch, and meter stick to each lab group.

Ask the following questions, in writing:

Describe the motion of the car as it rolls along the table.
How can you tell what it is doing?
What do you need to know to find the speed of your Stomper?
Find the average speed of your stomper over a distance of 1 meter.
What can you measure?   How many trials should you try?
Record your measurements and calculations.

Is this a constant speed? How can you tell?
Find the average speed for 2 meters.
Was it the same as the average speed for 1 meter?
What about 3 meters?

Graph the Distance Traveled vs the Time Taken for 1, 2 and 3 meters.
Describe this graph.
Is it straight?
Is this constant motion or changing motion?
What is the relationship between the Distance Traveled and the Time Taken?
Look at the slope (rise over run) of the graph, and calculate this slope.
What does this tell you?

Part II: Car Rolling Down Hill

Trade the toy car for the Stomper.

Help your students create a hill.
Ask your students the following questions, also in writing.

Start your car at the top of the hill.
Describe its motion.
Is it constant motion? Or is it accelerated (changing) motion?

Find the average speed of your car for 1/2 meter.
Record your measurements and calculations.

Repeat for 1 and 1 1/2 meters (or the end of the hill)
What do these speeds tell you? Is it constant motion, or accelerated motion?

Graph the Distance Traveled vs the Time Taken.
Describe this graph. Is this a straight line?
What does this graph tell you about the motion of the car rolling down the hill?

Performance Assessment:

Two possible follow up assessments:

1. Use a "Two Speed" Friction powered car. Wind it up and let it go. Ask for descriptions of its motion. Then ask for a sketch of a distance vs time. It will have a section of constant motion, then shift gears, accelerate, and have a new, faster constant motion.
2. Draw a graph of some motion, and ask for a description of that motion.

Conclusions:

Students should be able to measure distance and time.
They should be able to combine them to find speed.
They should be able to graph distance vs time, and find the slope to find the speed.
They should recognize the difference between constant motion and accelerated motion.
They may even be able to tell the difference in the motions by the sound of the cars as they roll along.

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Aviation

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Objectives:

This mini-tech is designed for the primary grades but can be modified for middle school grade levels. The main objective for this mini-teach is for students to understand that objects are launched in different ways and fly through the air in different ways. Additionally, students are to understand how to adjust paper airplanes and helicopters to fly better.

Materials Needed:

The following list is every item you will needed to complete this lesson in your classroom.

1. plastic helicopter dart available at American Science and Surplus $5
2. white piece of paper for each student
3. kite
4. stomp rocket available at American Science and Surplus $25
5. 10 paper plates
6. stapler
7. scissors

Strategy:

Intro: 10-15 min.
Demonstrate the helicopter dart and ask students to watch how it takes off and how it flies in the air. Then allow students the opportunity to play with the dart. Next, have a class discussion asking the students how it was launched and how it flew in the air.

Journal Writing: 10-15 min
Have each student write in their journal how they think the plastic helicopter dart was launched and how it flew.

Group Activities: 10-15 min
Divide the students into four groups. Group 1 will put together a kite and practice flying it outside. Each person in Group 2 to will make flying disk. Students take two paper plates and cut a small hole in the center of them. Next, face the tops of the paper plates together and staple together around the edges. Group 3 will make paper helicopter. Students will cut a 2 inch wide strip of paper 12 inches long and tear it in the middle at the top of the strip as far down as they would like without tearing the paper strip in half. Next, students will fold the bottom of the paper strip to add weight. Students then fold the torn part of the helicopter down in opposite directions. Group 4 will make paper airplanes in any design of their choice.

Group Discussion: 15-20 min
Have one or two students from each group demonstrate how their flying object works. Ask presenters of the flying objects to verbally state how they were able to get the object to fly and how it reacted in the air.

Measuring flight: 15-20 min

Have one student fly their object and then measure the distance in no standard unit of measure (foot to foot). Then have 3 to 4 students fly their object from the same place and compare and contrast the distance the objects flew. Ask questions like, "Who's flew the furthest and who's flew the shortest?"

Following the above have each student make the paper helicopters and measure the time it takes to fly a distance of your choice by clap timing. The class will clap the same beat and count the number of claps it take the paper helicopters to hit the ground when launched from a specific spot.

Closing:

Show the students a stomp rocket and ask how they think it will be launched and how it will fly through the air. Next, demonstrate how the rocket works and then allow the students time to play with it.

Homework:

Have the students bring in an object from home that flies or a picture of of something that flies and explain to the class how it is launched and how it flies.

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Newton's Third Law

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Objective:

This mini teach is designed for grades K-2. Children will use inquiry and observation skills to determine **Newton's Third Law of Motion**; for every action there is a reaction; for every force there is an equal and opposite force.

Materials Needed:

(see below group & individual activities)

Individual Activities:

(Stations 1-6 are individual student stations)
Each station should have an instruction sheet with helpful illustrations.

Group Activities:

Balloon Races
Balloons (different shapes & sizes)
Straws, Tape, String

Canister Explosion
Alka-Seltzer(Bicarbonate), 2-35-mm film canisters

Skate Board
2-Skate Boards or 2-Office Chairs

Wrap up surprise
2-Soft drink cans; 2-3 firecrackers (teachers' use only)

==

Individual Stations:

Station #1- Stomper Truck
Stomper Truck, 4x6 piece of cardboard paper, BB's/beads
1. Place cardboard on top of the beads.
2. Next place stomper truck on top of cardboard and turn stomper on.
Ask Question: What do you think will happen?

Station #2- Newton Scales
Newton Scales-2
1. Connect spring scales together
2. Person #1: pulls so that the scale stops on the number 20.
3. Person #2: does not pull.
Question: What do you think each scale will register?

Station #3- Books
Books
1. Person #1: Places books in person #2 hands.
2. Person #2: extends palms up to hold books.
3. Person #1: quickly remove books from person #2's hands.

Station #4-Pyramid
(2-person exercise)
1. 2 persons stand facing each other with palms of hands touching each other.
2. Each person will continue touching and moving feet backwards until they form a triangle.

Question: Who's pushing whom?

Station #5-Weight Scales
Bathroom Scales
1.Each person stands on scale puts hands under lip of table. Pull upward on the edge of the table.
Question: How much do you weigh while doing this?
2. Next, while standing on scales push down on table top.
How much do you weigh while doing this?

Station #6-Step Off
1 Skateboard
1. Step upon the skateboard.
2. Take one step forward, as if walking off the skateboard.

Please have someone hold onto your hands!!!
Question: Describe what you think will happened?

Strategy:

Group Activities
1st Group Activity: Balloon Race will serve as opening activity which allows group to do a cooperative activity together. This activity demonstrates "Newton's Third Law of Motion." By showing the students, when the air in the balloon is pushed out of the balloon, the escaping air pushes forward on the balloon. Allow students to test different hypotheses. What would happen if the balloons were filled with more air? What would happen if the balloons were raced up hill?

How To Construct Balloons For Race:
Determine how long the string needs to be for races (5-6 ft. per racer). Feed string through the straw (useful hint: make a threader out of floral wire, when finished it should look like a bobbie pin; this device needs to be longer than the straw you will be using, it allows for easier feeding of string through the straw). Attach straw and string to balloon with tape. Each contestant's string is attached to the wall/board and held in one hand. The other hand is holding the balloon that will be released at the start of the race.

2nd Group Activity: Station #3-Skate Board
2-Skate Board (you can use in place of skateboards 2-Office Chairs). This activity has two persons standing on skateboards and their palms touching each other. Then they push off from each other. Ask what do you think will happen? Each person should be propelled backwards (opposite directions). If you do not have a skateboard use 2 office chairs and have persons sit facing each other with palms touching. Ask them to push off and see what happens.

Performance Assessment:

(SURPRISE EXERCISE): Introduce students to soft drink device consisting of two cans and one firecracker. Then ask them what do they think will happen when the firecracker is placeed between the cans and lit. Have them write their conclusions in their journals. This will allow you to see if the children truly understand: **For every action force there is an equal and opposite reaction force.**

Alternate Activity: (You can use the two 35mm film canisters and Alka-Seltzer (Bicarbonate in place of the firecracker activity if you like; same conclusions will be drawn). The firecracker is just more dramatic. In order to use film canisters, half fill the two 35mm canisters with H_2O. Close the lid on one of the canisters and lay it down on the table on its side. Add the 1/2 tablet of Alka-Seltzer **quickly** to the 2nd canister. Quickly put the cap on and lay it quickly on its side with the lids facing each other. This is an alternate to the use of a firecracker in class.

Conclusions:

From a philosophical point, for every action in life there is a reaction.
If you touch the world gently....the world will touch you back gently. If you touch the world harshly the world will touch you harshly.

References:

Conceptual Physics by Paul Hewitt
Encarta

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Motion of a Bowling Ball

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Objectives:

The students will be able to make a distance vs. time graph of a bowling ball and have practice reading distance vs. time graphs of various motions.

Materials:

A bowling ball, 5 - 10 stopwatches, a massive object to let the ball collide into and not hurt anyone, white boards (this is a 8 foot by 4 foot sheet of white paneling board that can be bought at most big hardware stores and is cut into 1 foot x 1 foot boards), dry erase markers, and paper towels to clean off the boards.

Strategies:

Phase 1:
This is a Socratic/phenomenological form of questioning to do a lab. One of the "hidden" purposes to this lab is to get away from the standard, cookbook forms of the lab manual, and have the students make the plan of attack with small prompts from the teacher. I will repeat, you want to get away from the "now we'll do this" and move toward the "What do we need to do in order to make a distance vs. time graph of a bowling ball as it rolls?"

In your mind, you know you want to have the students line at equally spaced distances (for example every five feet) in the hall way. You could be courteous with your fellow teachers and warn them a day or two ahead of time. I think it is worth the extra trouble because this is an excellent opportunity to do science outside of the classroom - which is an entire other story. You would like stopwatches in there little hands. You would like the students to all start there stopwatches when you roll the bowling ball slowly. When the ball passes them you would like them to stop their stop watches. You would like someone to collect the data in a column form so that you can make another trial rolling the ball faster. You would like them to go into the classroom and graph the data (distance on the vertical axis and time on the horizontal axis). You can them ask questions such as "What do you notice about the best fit lines of the two trials?" Hopefully you will get the faster trial is steeper and the slower trial is less steep.

Now is a good time to regroup and explain that if the line is horizontal it means the object is stopped and the slope of the line (steepness) tells the speed.

Phase 2
Hand out the white boards and dry erase markers and a paper towel to clean them off. Explain to the students you are going to walk across the front of the class room and you would like them to make a sketch of a distance vs time graph (qualitative graph) of your motion. The following are some suggested motions to walk in order to have the students build from simple to more complicated.

a) walk at a constant speed
b) walk at a constant speed, stop for a time and walk at the original speed
c) walk at a constant speed, stop for a time and walk at a speed faster than the original speed
d) walk slow and then speed up
e) walk fast and then slow down
f) walk forward at a constant speed and then back toward the origin

Phase 3:
Have two students come up to the front of the class room. Have one student make a distance vs. time graph but not show anyone except the other student in front. He will try to walk like the sketch the first student made and the rest of the students will make a sketch of how the walking student walked. Compare the original sketch made by the first student

Performance Assessment:

Walk some method and have the students make a distance vs. time graph of your motion.

Conclusions:

On a distance vs. time graph the slope (steepness) of the line tells you about the speed of the object. The larger the slope (steeper the line) the faster the object travels. The smaller the slope (the less steep the line), the slower the object. A flat line means the object has stopped.

References:
Me: Give me a call.

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Strings and Springs

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Objective:

By measuring several periodic phenomena, the student will make graphs and determine what the different shapes indicate.

Materials:

Two springs
Two strings slightly longer than 1 m
120 washers
Four stopwatches

Strategy:

The activities will be in four separate stations. The students will divide into groups of four or five and circulate through the stations.

Station 1 The Bouncy Spring
Hang the spring vertically. Hang 10 washers from the spring. Lift the washers slightly and let them go. Measure the time for 20 bounces. Record the data in a table. Repeat with 20, 30, 40, and 50 washers. Make a graph of the data.

Station 2 The Stretchy Spring
Hang the spring vertically and notice the position of the end. Hang 5 washers from the spring and measure how far it stretched. Record the data in a table. Repeat with 10, 15, 20, and 25 washers. Make a graph of the data.

Station 3 Mass and Time
Hang a string so that it is 1 m long. Attach 5 washers to the end of the string. Pull the washers to to side slightly and let them go. Measure the time for 20 swings. Record the data in a table. Repeat with 10, 15, 20, and 25 washers. Make a graph of the data.

Station 4 Length and Time
Hang a string and make loops at 20 cm, 40 cm, 60 cm, 80 cm, and 100 cm from the top. Hang 15 washers from the first loop. Pull the washers to the side slightly and let them go. Measure the time for 20 swings. Record the data in a table. Repeat for the other loops. Make a graph of the data.

Performance Assessment:

Given pictures of several differently shaped graphs, determine which graph matches which station.

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Super-Ball Physics

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Objectives:

To study the motion of a ball in the air, its collision with a hard surface, and subsequent bouncing. The idea is to take an familiar toy and use it to demonstrate basic features of moving and colliding objects.

Materials Needed:

A large supply of various types of balls to demonstrate some that bounce well, some that don't bounce at all, and some that bounce only a few times. A meter stick [or better, a two meter stick] is needed for each set-up.

Strategy:

1. Begin by showing a variety of balls that bounce to different degrees and with different vigor on a hard surface [table or floor]. Show that Super-Balls of various shapes and sizes bounce more strongly than tennis balls, ping-pong balls, soccer balls, etc. Then give each team of two or three students a Super-Ball and have each team release the ball from a specified height. Have the students measure the "bounce height" of their balls, and enter their measurements on the board, as shown below:

Little Super-Balls

Release Height	Bounce Height
0 cm	0 cm
25 cm	_____ cm
50 cm	_____ cm
75 cm	_____ cm
100 cm	_____ cm
125 cm	_____ cm
150 cm	_____ cm

Draw a graph of bounce height [vertical] versus release height [horizontal] for the various types of objects, and note that the graph is roughly a straight line passing through the origin.

2. The next phase is to study how many times the **Super-Ball** bounces in the vicinity of the spot at which it makes initial contact with the floor. It is convenient to use the tiles on a tile floor, which are squares of standard size [8 x 8 inches, or 12 X 12 inches]. Give each group a Super-Ball and a ruler, have them drop the ball a specified distance above the center of a tile, and record their data in a chart on the board, like the one below:

Little Super-Balls

Drop Height	Number of Bounces
25 cm	____
50 cm	____
75 cm	____
100 cm	____
125 cm	____
150 cm	____

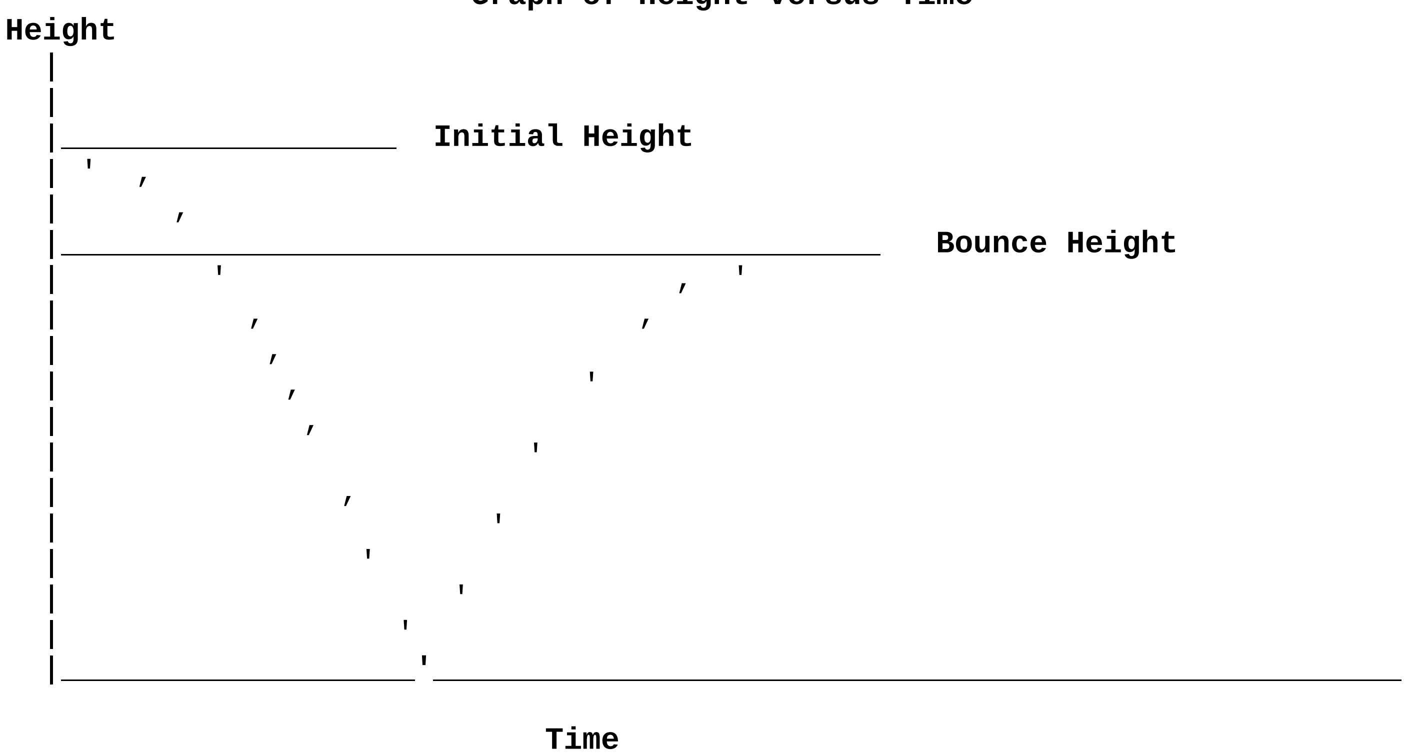
You would expect to see that the balls will bounce only a few times within the alloted square. In general, the balls bounce fewer times inside the region when they are dropped from a greater height. This tendency of balls to wander from the drop point is a reflection of their **chaotic** motion, a feature that they have in common with motion of the invisible molecules in a gas.

Performance Assessment:

Draw a graph of the vertical component of height of the **Super-Ball** above the floor/table [vertical axis] as a function of time [horizontal axis].

Acceptable solution: Note that the ball starts out at an **initial height** at the initial time, starts down slowly, picks up speed, and hits the table/floor after some time. Then it bounces upward, coming up to a **bounce height** that is somewhat less that the height from which it was dropped.

Graph of Height versus Time



Conclusions:

The Super-Ball can be used to illustrate a variety of basic concepts of motion [kinematics]. Its relatively elastic behavior makes it well-suited to illustrating the incessant motion of molecules.

Alternate Performance Assessment:

"A **Wham-O Super-Ball** is a hard spherical ball. The bounces of a Super-Ball on a surface with friction are essentially elastic and non-slip at the point of contact. How should you throw a **Super-Ball** if you want it to bounce back and forth? [**Super-Ball** is a registered trademark of **Wham-O Corporation.** San Gabriel, California.]"

This problem is taken from the book

Newbury, Newman, Ruhl, Staggs, and Thorsen
Princeton Problems in Physics [with solutions]
Princeton University Press 1991
ISBN 0-691-02449-9

The analytic solution to this problem appears in that book. It is shown there that the initial horizontal velocity v, the radius a of the ball, and the initial angular velocity w are related by

$$v = 0.4 w a$$

in order for the ball to bounce elastically back and forth.

The performance-based exercise involves launching a super-ball with just the right horizontal speed and spin so that it will bounce back and forth on the floor.

References:

Additional information and phenomenological exercises on the Super-Ball [and a myriad of other interesting matters!] are described in the classic reference

Jearl Walker
The Flying Circus of Physics with Answers
Wiley 1977
ISBN 0-471-02984-X

Exercises **2.18** [The Super-Ball as a Deadly Weapon] and **2.28** [Super-Ball Tricks] are directly relevant.

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Inertia

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Objectives:

Inertia

1. Playing card and nickel
   Balance a playing card with a nickel on your index finger. Then with your other hand, try to flick the card out from under the nickel so that the card flies out but the nickel stays on your finger.

2. Tablecloth
   Pull the tablecloth out from under a set of dishes. Fill the cups and glasses with water first.

3. Blocks and glass
   Put a full glass of water on a stack of 6 3"x3"x1" blocks and use a support pole to knock out the bottom blocks.

4. Stack of nickels
   You can knock the nickels out of the bottom of a stack with a credit card.

General Conclusion:

The more weight an object has, the less it moves if you exert the force quickly.

5. Weight and string
   Use thread to suspend a 400g weight and tie another thread below. If you pull fast the lower thread breaks, and if you pull slow the upper thread breaks.

6. Barbie and Ken
   Barbie uses her seat belt and Ken doesn't, so Ken shoots out of the car.

Test:

Put a clothes pin on an embroidery hoop and balance it on a wide mouth bottle. Ask what will happen if you jerk the hoop out. Explain using the idea of inertia.

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Momentum

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Objectives:

The main objective of this mini-teach is to demonstrate the concept of momentum. The lesson is designed for grade levels 3, 4, and 5.

Materials Needed:

3 dynamics carts
hammer
block of wood
Jensen Bar
marked off measurements
4 empty pop cans
small fire cracker
skates
tape measure

Strategy:

1. Hold the cart in your hand and demonstrate how the cart works by releasing the spring. Ask the students, "What happens when I release the spring? Why doesn't it go?"

2. Take the cart and place it next to a wooden block. Ask the students "What do you think will happen when I release the spring?" Get their responses. Ask, "What happened?"

3. Take 2 carts back to back and place on a wooden board (platform). Ask the class what will happen? Release the cart and measure the distance. What happened?

4. Compare the results of the equal carts with the cart against the block. Did they do the same thing?

5. Double the weight of one cart by placing a cart on top of another cart. Ask class what will happen. Get response and then release the spring.

6. Place a block at each end of a flat board. Place a single cart back to back with a double cart. Ask the class how the carts should be placed so that they will hit the blocks at the same time. "What can we say?" Write on the board that "lighter" is faster and "heavier" is slower.

7. Place 2 single carts on a balance board or teeter totter. What will happen when the spring is released? Will they stay balanced?

8. Place 2 unequal carts on teeter totter and ask how you should move carts so they reach end of board at the same time and the board remains balanced.

Explain that when the heavier cart is half as far from pivot the board is always balanced. This only happens if the speeds are 2:1.

9. Take out the Jensen Bar and ask if you move the heavier weight on one hook where do you move the lighter weight to balance? Compare this information with where the carts land on the teeter totter. Ask class if the distance is the same ratio. Jensen Bar shows 2 mass x 1 distance = 1 mass x 2 distance. Momentum shows that 2 mass x 1 speed = 1 mass x 2 speeds. When the total momentum is zero the teeter totter is balanced.

10. Place 3 carts back to back and release the springs. What happens?

11. Have 2 children on skates face to face and ask what is going to happen if they push off of each other. Have the children push off and observe.

12. Have the skaters facing the same direction. What will happen when the skater in back pushes from behind? Have skaters do this.

13. Using 4 or 5 skaters lined up - ask what is going to happen when skater at the end pushes skater in front and then each one every 2 seconds pushes the other. Have the skaters enact this. For variety have skaters randomly change their order and see what happens.

14. Take 2 empty pop cans of equal weight and place a fire cracker taped between them. Ask what will happen. Set off the fire cracker. Now repeat this, but this time have some melted wax in only one can, so that it is twice the mass of the other, but do not let the students know.

Performance Assessment:

Do not tell students that the weight in one of the cans is heavier. As an assessment ask what happened when the 2 cans were set off and explain why.

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Kinetic Energy and Work

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Objective:

Kinetic energy can be thought of as the energy associated with the motion of an object and is equivalent to work. An example of kinetic energy is a moving hammer doing work on a nail. The hammer does work on the nail by driving it into the wall.

The main objective of this Mini-teach is for students to observe kinetic energy in balls of the same size but of different mass. Students are to see that balls with a greater mass (weight) and greater height (velocity), have more kinetic energy than balls with a lesser mass (weight) and a lower height (velocity). They will be able to observe this by rolling balls of various masses down a ramp at various heights and measuring the distance the ball moves a block wall. In addition, students will be able to graph the relationship between the distance the block wall moves versus the mass of each ball.

This Mini-teach can be used for grades 5-12.

Materials Needed:

For each group:
(1) ramp with rails
(2) rails
(1) block wall
(3) balls (same size, different mass)
(1) meter stick
(6) blocks
(1) balance

Strategy:

First, obtain three balls of about the same size but, of different mass. Weigh the balls on a balance to determine the mass. Record the mass in grams. Next create three data tables according to the number of blocks used, (2, 4 or 6). In the first column of the data table, list the three balls according to their mass starting from the least to greatest. For the next three columns, label them "trial 1", "trial 2" and "trial 3". Label the final column "average". This is where you will record the average distance of the three trials.

To obtain the first set of data for the first data table, stack the two blocks on top of each other. Place the ramp on top of the blocks on an angle. At the bottom of the ramp, place each of the rails next to each other leaving a space between them. Place the block wall securely between the two rails. Starting at the top of the ramp, roll the first of the three balls down the ramp. Allow the ball to hit the block wall until it has used up all of its energy **(until the ball comes to a complete stop)**. Measure the distance the block has moved with a meter stick. Remember to measure the distance from the end of the ramp to the beginning of the block wall.

Repeat these steps two more times using the same ball at the same height. Perform these same steps using the two other balls at the same height. Do this for each ball at each height (4 and 6 blocks). Record the data in the data charts.

Finally, use the average distances and the mass of the balls to make a graph. Place the average distances on the x-axis and the mass of the balls on the y-axis.

Performance Assessment:

The performance assessment used in this mini-teach is breaking a piece of wood with your hand. This is done by securing a piece of wood on a board holder so that it won't move. Next, make a fist with your hand making sure that your thumb is on the outside of your fist. Lastly, with a very constant motion, force and upward swing of your body, strike the middle of the board. Surprise, the board breaks!

Question:
How do you have to move your hand to do the most work in order to break the board?

Answer:
In order to do the most work and thus break the board, you must hit the board very fast and at a constant speed. The board should also be hit on the grain of the wood because this is where the board is weakest. Finally, your hand should hit the board from a high distance to increase the amount of kinetic energy in your hand.

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How to speed up a slow Grandfather - The Pendulum

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Objectives:

To introduce the concept of periodic motion and relate it to its use in a Grandfather type clock. To discover that the period of a pendulum is dependent on the length of the pendulum and independent of the weight of the bob and the amplitude. Students will discover that a slow running Grandfather clock can be corrected by changing the length of the pendulum.

Materials:

Each group needs a stop watch, pendulum and metal washers.
Materials needed for a pendulum are string and paper clip.
To make a play Grandfather clock you will need a ringstand and a rod and a clockface made from paper.

Strategy:

Begin the class by saying "I'm sure your all wondering why I called you here at this time. In my hand I hold a memo from our CEO that threatens our jobs. We have been given one hour to solve a problem that a has caused a hugh drop in sales." Point to the play clock. "As you can see our clock is five minutes slow. In a moment we will break into our work groups and start working on possible solutions to our problem: What can be done to the pendulum to have the clock run on time?"

At this time you may want a student to come to the front to point out the pivot point, length, and bob. Be sure to demonstrate what a cycle is and how to count cycles. Next pass out a pretend memo from the OLD TYME CLOCK CORP. The memo should state the problem and indicate they may be fired if they do not solve the problem by the end of the period. Each group is given a different length of string to create a pendulum. Lengths may vary from 25cm to 2m. Each group will find the time for their pendulum for 20 cycles. On the board draw a graph with numbers across the top indicating time in seconds. Start with zero using 5 second periods, up to 50 seconds.

When the students have found the number of seconds per 20 cycles ask the students to come forward and tape their pendulum at the appropriate time. Once all the groups have taped their pendulum to the graph, discuss the results. Students will hopefully see the direct relationship between the length and the period of time. Next, each group is given a string of the same length, but this time students may add different numbers of washers. As before the groups will find the period of their pendulum and then come to the front to tape their pendulum on another graph. Hopefully the students will understand the idea that the weight of the bob does not influence the period of the pendulum. Lastly, you should demonstrate the effect of amplitude on a pendulum. You could probably do this in front with help of a student. At this point you should compare the three variables; length, weight and amplitude. Using the collected data ask the students to write their solution to correcting the problem of the slow grandfather clock.

Performance Assessment:

This activity will take more than one period, a good place to break would be after finding the effect of length on a pendulum. For assessment, students should be able to describe what should done to the pendulum and explain how this would solve the problem. The student's understanding of this material can be evaluated by having them predict what the correct length would be for the clock to kept the correct time. Hopefully by experimenting students will discover the length at 20 seconds is the correct length.

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Newton's Third Law Of Motion

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Objective:

This mini-teach is designed for grades 4 - 6. Pupils will verbalize and demonstrate Newton's 3rd Law of Motion: action and reaction.

Materials Needed:

These materials will be used for teams of five - six pupils.

string
tape
long party balloons
straws (milkshake size)
masking tape
scissors
empty soda pop can with the opener lever intact
nail
bucket/tub of water
11 x 14 piece of cardboard
marbles
ten foot nylon rope
wind-up Tomy truck
giant skateboard (about 20 ft.)
timer (clock)
two demo spring scales
fan cart (Pasco dynamics cart w/ personal face fan attached)
three foot skateboard

Strategy:

Rocket Launch:
Have four - five pupils attempt to get balloons across the room. Some may throw them across, blow them up and release them, or walk them across the room. Lead them to realize that they need a direction for their balloons. Now, have pupils inflate balloons as a team and launch them in races. The balloons slide along the strings on the thrust produced by escaping air. Then pupils discuss what happened and try to give reasons for what they observed. Next, teams travel through four stations which reinforce the idea of action/reaction. The stations are described below:

Stations	Activities
(1)	Soda Pop Can Hero Engine - Pupils observe water streaming through 4-6 holes (made by a nail) in the bottom of a suspended soda pop can. The water causes the can to rotate in the opposite direction from the direction of the streaming water.
(2)	Three foot skateboard - Pupils line up and step up on the skateboard, one at a time. As the pupils step off

the skateboard, they are to observe what happens. Safety Note: Have someone hold their hand as they step off the board.

(3) Truck and Marbles - Pupils space about 20 - 25 marbles evenly under a 11 x 14 square cardboard. Then a Tomy wind-up truck is placed carefully on the cardboard. When the lever is released, the pupils are to observe what happened.

(4) Demo Spring Scales - Pupils pair off and hook one demo spring scale to the hook of their partner's spring. One tries to pull with a force of 4 Newtons while their partner tries to pull at a force of 8 Newtons. Pupils will describe the situation and tell what happens and why.

Groups rotate every four minutes (teacher uses the timer to keep groups on task). At the end of the sixteen - twenty minutes, each group nominates a reporter to share the findings of their team.

As a closing activity, pupils play "Tug Of War" using the giant 20 foot skateboard. First, pupils pair off and join hands with their partners. A piece of masking tape marks the starting off position. Whichever partner comes over the tape, loses the round. Next, have a person with a small physique go against four larger people using the nylon rope, which is looped at both ends. Naturally, the small pupil loses. Then have the four larger pupils stand on the giant skateboard, and have pupils predict the outcome of the tug of war. The class discusses what happened and why. Then a general rule or law is produced through total group participation.

Assessment:

Groups write up their thoughts about each station and post their group's conclusions on the chalkboard. Selected persons report orally before the class.

Conclusion:

Fan Cart: Attach a personal fan to a Pasco dynamics cart with tape. Turn it on. The class concludes that the action of the blades on the fan is the cause of the cart gliding in the opposite direction. This gliding is the reaction force. Pupils form the general law which states that actions take place in pairs with reactions. For every action, there is an opposite (and equal) reaction. For example, with the Hero Engine, water streams in one direction and the can rotates in the opposite direction. With the truck and marbles' activity, the truck goes in one direction while the cardboard goes in the opposite direction. As the person steps off the skateboard, they exert an action force on the board, making it go in the opposite direction. Pupils found that they could not pull on opposite ends of the Demo Spring Scales with different amounts forces. As they pulled, the scales always read the same force. In every activity, pupils conclude that whether a balloon is racing along a string, or whether one is engaged in a tug of war, there will never be an action force exerted without a resulting reaction force.

References:

New Explorers: "Endeavors/Mae Jemison"
Globe's: Concepts and Challenges - Physics

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Objects Race 500

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Objective:

ALL GRADES

To determine how shape affects speed.

Materials Needed:

scale
balls
can of beef broth
Three yardsticks
Glass jar with lid
books or blocks
Clear plastic bottle
table
hoops
Various solid disks
can of mushroom soup
Two cans of Comet
construction paper
A smooth flat board
Blue food coloring
Four right angle screw clamps
Set of same mass/same size wooden hoop and metal disk (momentum set)
Set of same mass/same size/different distribution sticks (momentum sticks)

Strategy:

a. Set up incline plane.
b. Prior to lesson empty one container of Comet into the glass jar and seal the empty Comet container with the lid and set it aside out of sight. Collect twenty objects that roll smoothly from the material listed above.
c. Fill plastic bottle half full with water. Add a few drops of blue food coloring to the water. Set this aside out of sight.
d. Place pair of right angle screw clamps on opposite ends of one yardstick. Place pair of right angle screw clamps near the center of one yardstick allowing enough space to hold the yard stick between the clamps. Place the momentum sticks and set on the table off to one side.
e. Place scale on the table.
g. Make three signs: OBJECTS RACE 500, WINNERS, and NONWINNERS. Tape the signs WINNERS and NONWINNERS at bottom of the chalkboard tray at opposite ends.
h. Make an elimination grid by listing the numbers one through sixteen vertically on the board. Have children write down names of object next to number on the board. Start the race by calling children up with their objects. Place the objects at the high end of the incline plane. Align the objects behind a yardstick. Countdown from three to zero. Lift the yardstick straight up. Allow the objects to roll down the incline plane. The first object down the incline plane is the winner of that race. The nonwinning object is to be placed on the bottom ledge by the NONWINNERS sign. The winning object races the winner of the next race. Repeat process until all eight races are completed in the first round. If there is a tie try switching the position of racing the objects. Race objects back to back. If one object clearly pulls away from the other that object

will be faster. Ask the children to make observations about the nonwinning objects and do the same for the winning objects. Repeat the process until all races are completed. Ask the children to make observations about the winning objects and the nonwinning objects.

i. Tell the children that you would like to have some fantasy races with more objects. Proceed with these pairings for the races: the momentum set, the can of beef broth and mushroom soup, can of beef broth and wooden disk and the last race will be the empty can of Comet and the full can of Comet.

j. Ask the children to predict which object do they think will win in each of fantasy races.

k. The results will be that the wooden disk will be faster than the metal hoop. The can of beef broth will be faster than the can of mushroom soup. The empty can of Comet will be faster than the full can of Comet. The full can of Comet will roll a little distance and then come to a full stop. The beef broth will beat the metal hoop because the liquid inside is sliding down the incline. Illustrate this by rolling the bottle of blue water down the ramp.

l. Use the momentum sticks. Swing the sticks out away from your body. It will be easier to swing the momentum stick that has its mass closer towards the center than the one that has the mass distributed towards the end. This can be illustrated by repeating the swings with the yardsticks. The yardstick with the right angle clamps near the end illustrates the metal hoop and the empty can of Comet. The yardstick with the right angle clamps near the middle illustrates solids such as the wooden disks, balls, and the can of mushroom soup.

m. Look again at the race between the momentum set(wooden disk and metal hoop). Show with the scale that both objects have the same mass. Remind them that the disk was faster than the hoop. Ask the children to make observations. Is weight a factor? No it is not. The faster objects have a center of gravity closer towards the middle similar to the yardstick with the right angle clamp near the middle. The hoops have their center of gravity distributed closer to the rim illustrated by the other yardstick with the clamps attached at the end.

n. The full can of Comet was the slowest because the powder inside was also turning trying to reach its own center of gravity while the can was rolling down incline. Illustrate this by rolling the glass bottle of Comet down the incline.

Performance Assessment:

Rank these objects in the order that they would finish in a fantasy race and tell why each object finished in that order. Use a disk, a can of soda, a hoop and a ball.

Reference:

Two hundred and one awesome, magical, bizarre, and incredible experiments by Janice VanCleave.

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Newton's Second Law; Mass-Acceleration Relationship with Dynamics Carts

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Objectives:

Students will form their own hypothesis about the relationships between force, mass, and acceleration for their dynamics cart system. First they will qualitatively evaluate a cart system, then collect actual data, then express the data in graphical format to visualize the relationships. This mini-teach is geared for the high school physics student. Minor adaptations can be used for lower grades. CBL units can also be implemented for more advanced high school physics students.

Materials Needed:

Classroom set:
2 different mass automobiles (van & car)
2 bathroom scales (cheap flat ones)
7 dynamics carts
7 table clamp pulleys
7 1.8 meter lengths of string
7 100 gram masses
28 1 kg masses
7 startwatches
7 dynamics cart stoppers
7 calculators

Strategy:

The concepts of force, mass, and acceleration are reviewed with students first. Question: If I push on a car with a constant force, then push on a van with the same constant force, which will accelerate at a higher rate? Let's try it!

Have two students push on a small car with bathroom scales under their hands against the bumpers. Have them push straight ahead, trying to keep the scales at a constant force. Students qualitatively measure the car's acceleration rate. Now two students push on a mini-van with bathroom scales under their hands against the bumper. Students again qualitatively measure the van's acceleration rate. The teacher should be "secretly" calculating the actual acceleration rate of both vehicles using $d = 1/2*a*t^2$.

Ask students to formulate their own conjectures about the relationship between mass and acceleration for objects being pushed or pulled. Students will now complete the following lab.

NEWTON'S 2ND LAW: MASS-ACCELERATION RELATIONSHIP

DIRECTIONS:

1. Assemble your dynamics cart system as follows, be certain cart does not hit pulley. Connect string to cart and hang 100 gram mass over edge of pulley. Place wood stopper block in front of pulley to stop the cart from smashing it. Pull car back on table top until hanging mass is just below pulley, mark the

front of the cart's position on the table with tape. Let cart travel one meter in a straight line towards the pulley, mark one meter traveled position on the table. Be certain the hanging mass still has not touched the ground when cart is at the one meter position.

2. Your cart will be allowed to travel one meter over your table surface. The cart needs to travel the full meter before the attached hanging mass hits the ground.

3. With your startwatch, find the time from the release of the cart to the point that the cart has traveled exactly one meter. Time each trial three times for each amount of mass added to the cart.

4. Average your three time trials for each amount of mass added to the cart, then calculate the average acceleration rate of your cart by using acceleration = $1/(\text{time})^2$.

5. Complete the following data table with your group, then be prepared to graph your results. Do you notice anything about the acceleration rate of the dynamics cart?

Data Table:

Hanging Mass	Cart+Mass	Time 1	Time 2	Time 3	Avg Time	Acc ($1/t^2$)
100 grams	cart					
100 grams	cart + 1kg					
100 grams	cart + 2kg					
100 grams	cart + 3kg					
100 grams	cart + 4kg					

6. After individual groups complete data table, they shall complete a graph of acceleration vs. cart's mass on 2ft x 2ft dry erase boards.

7. Look for similarities and differences between the groups graphs, making changes if necessary.

8. From your table what can you say about mass-acceleration relationship?

9. From your graph what can you say about mass-acceleration relationship?

10. Does the graph and table have a similar relationship for mass-acceleration?

11. Does the graph and table support or change your original conjecture?

Discussion:
Ok, Newton's 2nd Law says that the net force on an object is equal to the objects mass times the objects net acceleration. Or, F=m*a.
Since we kept the net hanging force a constant size, what would happen to the acceleration if we made the mass larger? F=M*a
What would happen to the objects acceleration if we made the mass small? F=m*A

Performance Assessment:

Give students the acceleration rate of either the car or van from the opening activity. Recall what force the scales showed, in pounds, then convert them to the metric units of force (Newtons). Students now need to calculate the car or van's mass from this data. After results are collected we can find the experimental error in the vehicles mass calculation. If the performance assessment tool above is used, you will need to find the force of friction of the vehicle at a constant speed to obtain an accurate NET force of motion and calculate an accurate vehicle mass.

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Potential Energy

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Objective:

The main objective of this mini teach is to introduce the concept of potential energy. The students will recognize that potential energy is the ability to do work. The students will identify the two factors that effect potential energy. The following activities will demonstrate the effect of height and weight on potential energy. The activities are designed for the intermediate level.

Materials Needed:

weights	wooden blocks	tennis ball	rubber bands
nails	empty spools	meter stick	
hammer	wooden matches	string	
flat empty can	paper clips	ruler with center groove	
large rock	scotch tape	scissors	
pebble	buttons	books of various widths	

Strategy:

Activity - How does the weight of an object effect its gravitational potential energy.

1 Lift the pebble and the stone from the floor to the table.
2 Place the flat can on it's side on floor near the table.
3 Predict what will happen the pebble is pushed off the table and hits the can.
4 Predict what will happen when the large stone is pushed off the table and hits the can.

Activity - The effect height has on the energy of an moving object.

1 Cut an 1 in. square section in the top of a paper cup.
2 Place the cup over the ruler. The end of the ruler should touch the back of the cup.
3 Raise the opposite end of the ruler and rest it on the pencil.
4 Place the marble in the center groove at the ruler's highest end.
5 Release the marble and observe.
6 Repeat the steps above substituting books of various widths for the pencil.

Activity - The effect weight has on potential energy

1 Attach the string to handle of the pail.
2 Secure the opposite end of the string to the edge of the table. The string needs to be long enough to allow the pail to swing about one inch above the floor.
3 Place the paper on the floor under the hanging pail.
4 Position the wooden block on floor in front of the pail.
5 Pull the pail back and allow it to swing into the block. Mark the position

that the block has moved to on the paper.
6 Repeat the steps above adding large pieces of clay to add weight to the bucket.

Activity - The effect weight has on potential energy

1 Cut a 2 inch square section in the top of a paper cup.
2 Place the cup over the ruler. The end of the ruler should touch the back of the cup.
3 Raise the opposite end of the ruler and rest it on the book.
4 Place the small marble in the center groove at the ruler's highest end.
5 Release the marble and observe.
6 Repeat the steps above substituting the large marble.

Activity - Height and potential energy

1 Position the 50 gram weight directly over the first nail.
2 Lift the 50 gram weight to six inches as marked on the wooden bar.
3 Release the weight and observe.
4 Repeat the steps above raising the weight to 8 inches, 10 inches and 12 inches * If the first nail is damaged replace.

Activity - Weight and potential energy

1 Position the 20 gram weight directly over the first nail.
2 Lift the 20 gram weight to the top of the wooden bar.
3 Release the weight and observe.
4 Repeat the steps above substituting various weights.
  * If the first nail is damaged replace.

As a closing activity the student can make a motorized spool. This allows the student a hands, on at home, activity. The students will construct the spool and answer a series of questions. This also serves an evaluative tool.

Activity - The motorized spool

1 Loop the rubber band through two of the holes in the button.
2 Make a small hole in the end of the paper clip and use it to pull the rubber band through the hole in the spool.
3 Hold the rubber band in place in the spool by inserting a short length of a Q-tip or a piece of the wooden match through the ends of the band. Use small pieces of tape to hold the stick in place.
4 Insert a Q-tip or match through the other end of the rubber band, the head of the match or one end of the Q-tip near the hole, and the other end extending out beyond the edge of the spool.
5 Using the long end of the stick, wind the rubber band 5 times. Place it on it's side on a table and let it go. Observe the result.
6 Explain what happened to the spool when it was placed on the table?
7 Why did you have to wind the elastic band?
8 Explain where the energy came from to drive the spool.
9 Wind the spool again 5 times and using the ruler measure how it travels.
10 Predict what will happen if you wind the band 10 times. Test your prediction by winding the band 10 times and letting it go on the table. Describe the result of your prediction.
11 Experiment with your motorized spool by measuring the distance it travels

when wound 10, 15, 20 times. Does the spool go twice as far with 20 turns as it did with 10 turns? Explain why it did or did not.

12 Wind the rubber band 10 times and hold the stick in place with a piece of tape. Put the spool away until the next day.

13 After storing the spool overnight remove the tape and release the spool on the table. How far does it go now?

14 How well did the rubber band store energy overnight?

The students will enjoy reporting their results the next day in class.

Each of the activities are designed to show increased height and or increased weight will increase potential energy.

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Momentum

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Objective:

This lesson is designed for primary level students. They will observe the transfer of momentum.

Materials Needed:

2 or more pairs of rollerblades
2 cars - each car has a spring attached to the front bumper and velcro attached to the rear bumper.
a weight (that will fit on one of the cars)
cue balls
cue stick
marbles
string

Strategy:

Begin with a roller blade demonstration. Tell the students they will need to observe what happens. Students of approximately the same weight will put on rollerblades and will participate in four demonstrations. (Be sure students wearing roller blades are also wearing helmets and other protective gear.)

l. One person stands still. The other person skates into him. At the point when they would collide, they push off from each other.

2. Repeat above, but this time, as they meet they grab on to each other.

3. Both students skate towards each other. When they meet, they push off from each other.

4. Repeat above, but this time, they grab on to each other.

This entire series can be repeated using one heavier student (or two students together) and one lighter student. See if the results are the same. If possible, let all students try these demonstrations with a partner.

Now repeat the demonstration using the 2 cars. The students will observe and discuss what they see. The teacher can draw the diagrams of the car's movement on the board.

1. One car moving - one car still. The springs on the cars are facing each other. Observation: The moving car stops and the still car moves in the same direction the moving car was going.

2. One car moving - one car still. The velcro on the cars is facing each other. Observation: The cars stick together and move slowly in the

direction the moving car was going.

3. Both cars moving towards each other. The springs on the cars are facing each other. Observation: Each car moves in the opposite direction but slower.

4. Both cars moving towards each other. The velcro on the cars is facing each other. Observation: The cars stop.

These demonstrations can be repeated putting a weight on one of the cars. Some of the observations will differ. Students should observe that movement transfers from one car to the other. This is called the transfer of momentum. They should also see that the weight of the car (or other object) affects the speed and direction of the movement.

Now do a demonstration using cue balls. Line up two cue balls. Have a student hit them with a cue stick so they move in an angle. Use a string to show where the ball was hit and the path each ball takes. The students should be able to see a 90 degree angle. Ask them if they see an "L". Repeat several times.

Now give the students a bag of different size marbles and string and let them try to see what kinds of angles are made when you hit two marbles together. Have them observe if the angle changes when the marbles are the same compared to when the marbles are different. Discuss the observations with the class.

Performance Assessment:

Students should be able to describe what "transfer" means, when discussing transfer of momentum.

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Projectiles

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Objective:

This miniteach is designed for grades 3-8. The student will be able to measure angle and distance of an arc.

Materials Needed:

balls
water guns
dartboard/darts
rubberbands
aluminum foil
plastic spoons
rocket gun
ping pong guns
bow and arrow
stopper guns
protractors
string
meter sticks

Strategy:

The class will observe a demonstration of a ball rolling off a table, thrown in the air, and rolling off of a ramp. The class will give a very short description of what they have observed.

There will be seven stations set up to observe.

1. Water guns
2. Dartboard/darts
3. Slingshots with a rubberband and aluminum foil
4. Catapults with the plastic spoon and aluminum foil
5. Rocket gun
6. Ping pong gun
7. Bow and arrow

The class will give a very short description of what they have observed.

Performance Assessment:

The class will break up into groups of four. Each group will get some stopper guns to measure the angle and the distance of the stopper. The angle will be measured using a protractor and string. The string will hang straight down in order to figure out the angle of the arc. The distance will be measured using a meter stick. The class will describe their observations and give a conclusion.

Conclusion:

The class will be able to answer this question: What angle was needed to get the greatest distance?

Answer: A forty-five degree angle will give the greatest distance.

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Newton's Second Law of Motion

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Objectives:

To verify Newton's Second Law of motion by a) subjecting a body to multiples of a force; b) subjecting two bodies to the same force and qualitatively describing what happens; then quantitatively, the acceleration produced by a gentle ramp. Data is collected, analyzed and graphed.

Materials Needed:

Coffee can, stop watch, meter stick-one each per group of five members. For the demonstration, a lab cart and strong slinky and pulleys, toy carts and weights.

Strategy:

The laboratory cart is kept fixed while a student sits on it holding one length of slinky which will be pulled by teacher till the cart begins to move. This approximates a constant external force. Now two such lengths are held by the student and motion studied. Next the cart is accelerated under three lengths. Conclusions are put up on the board.

The group gathers around the table to compare the accelerations produced by the same force acting on two masses in the ratio 1:2. The arrangement used is a fixed mass in a scale pan falling under its own weight. Conclusions are posted.

Now the groups are handed their equipment and led to the ramp. Marks are made at distances of 0, .50, 1.0, 2.0,meters on the ground and observers with stopwatches stationed there. The coffee can is let go and timings noted.

A graph of d/t is made showing accelerated motion. Each group computes average velocity and acceleration for each mark. To find out if the acceleration is constant, students graph v_{avg}/t. Results are discussed.

Performance Assessment:

Groups answer these questions:
1) What visual evidence have you that the three objects were not moving at constant speed?
2) How does your first graph support this?
3) Find the slope of your second graph. What does this represent?
4) What would happen to the value of acceleration if the ramp were made successively steeper? What setup would you use to show this?
5) What is the value of a when the ramp is vertical?
6) Show by a diagram all the forces acting on the coffee can and which constitutes the unbalanced force.

Conclusions:

1) a a F for constant m
2) a a 1/m for constant F
3) Graph of d/t is not a straight line but v_{avg}\t is, showing that acceleration produced on a fixed mass by a fixed force is constant.

References:

Personal Bank

distance from **x=0 in meters**	time to roll **to new mark(s)**	average velocity **from x=0**	Dv/Dt
0			
0.5			
1.0			
1.5			
2.0			
2.5			
3.0			
3.5			
4.0			

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Tops

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Objective:

This lesson is designed for primary level students. They will observe angular motion - precession.

Materials Needed:

Bicycle wheel - Put handles on the axle through the center. Fill the tire with sand or if no tire, get a vacuum cleaner hose. Fill it with sand and tape it to the rim. On one end of the handle attach a string.
Chair that rotates
Gyroscope
A variety of tops
Cardboard
Plastic lids of various sizes
Push pins
Round toothpicks
Wooden skewers
Scissors
Crayons
Compass
Tape
Glue gun

Strategy:

Hold up the bicycle tire by the handle and ask students to identify the item. Then hold the tire by the string and ask the students what they observe. It falls down. Next, hold the bicycle tire and have someone help to spin the tire. Now hold it by the string and ask students to observe what happens. As the bicycle wheel spins on its axis, it also rotates around the string. Students should note that it is spinning two different ways. You can introduce the vocabulary rotate or revolve.

Next, have a volunteer sit on the chair that rotates. Give them the bicycle wheel to hold and get it spinning. Ask them to angle it to the right or to the left. As the wheel angles to one direction or the other, the chair rotates in the same direction.

Last, ask for a volunteer that is a very good runner. Tell them they need to run straight ahead and then make a sharp turn. Have them practice. Then give them the wheel to hold and spin it for them. As they run and turn, they need to try to hold the wheel upright. They may want to try several times or ask for another volunteer. They will soon see they can't hold it upright. Ask for the student's observations and write them on the board.

Next, show them a gyroscope, and demonstrate some tops. Give the students time to play with the bicycle wheel, gyroscope and tops. After they have finished, ask for any observations they have made about tops and write them on the board.

Performance Assessment:

Students are to use the cardboard, plastic lids, toothpicks, push pins and skewers to make their own tops. They may decorate them. The tops work better if the pins, toothpicks or skewers are glued to the disks with the glue gun. If the top spins, the student was successful. Creativity in the shape of the disk is a plus. For Kindergarten or 1st graders, the teacher should poke the hole in the disk and help to attach the center post with the hot glue.

Extensions:

Disks can be also be used to show how colors mix or to demonstrate optical illusions.

References:

175 Science Experiments, Brenda Walpole, Random House, NY, l988, p. 155.

Simple Science Experiments With Everyday Materials, Muriel Mandell, Sterling Publishing Co., Inc. NY, 1990, pp. 40-41.

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Periodic Motion - The Pendulum

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Objectives:

To introduce the concept of periodic motion and relate it to the movement of a pendulum. To discover that the period of a pendulum is dependent on the length of the pendulum and independent of the bob and the amplitude.

Materials Needed:

Each group needs a stop watch and pendulum with a different bob.

Materials for pendulum -
string
bob - infant stacking rings provide colorful bobs of different sizes and mass
right angle clamp
ringstand
rod

For class graphs - two pieces of end roll paper approximately 21/2 meters long, a meter stick, markers and masking tape

Strategy:

Begin the class period with a discussion of what the students think periodic motion is. After a few minutes, bring out a pendulum from behind the lab table and use it as an example of periodic motion. Point out its various parts - bob, length, pivot point. Demonstrate what is meant by period and amplitude. Spend a few minutes discussing the accuracy of measuring a single period. The students should realize that timing how long it takes for ten cycles and dividing by 10 will lessen the effects of reaction time and result in a more accurate measurement of the period.

Break up the class into groups. Each group is given a pendulum with a different bob but all pendulums are 1 meter in length. (A different option would be to have the students construct their own pendulums 1 meter in length. If doing so, make sure to discuss that the length of the pendulum is measured from the pivot point to the center of gravity of the pendulum bob.) Each group is to find the period of their pendulum by timing it for 10 cycles and using an amplitude of 10 cm. After doing so, they are to experiment with other amplitudes (5 cm, 15 cm, 20 cm, etc.) to determine if the amplitude effects the period. All groups record their data in the class data table on the board under the following headings: Color of bob, Time for 10 cycles, Period, Effect of changing the amplitude.

When all groups have recorded their data, call the class together for a discussion of the results. It should be apparent that the shape and mass of the bob and the amplitude have no effect on the period. Small differences can be explained by experimental error. If the students are not sure that the rings are actually different masses, bring out a scale and prove it. If you are using infant stacking rings, there will be about a 50% difference between the largest and smallest ring's mass.

Each group is given a different length of string to create a new pendulum. Lengths should vary from 25 cm to 2 m. As before the groups will find the period of their pendulum. This time they will graph their results on a length versus period graph.

While the students are finding the period of their pendulums, hang a piece of end roll paper about 21/2 meters long on a wall and label the axes. The vertical axis is marked off to the actual length of the pendulum. The horizontal axis is the period marked in a convenient scale.

When the students have found the period of their pendulum they should remove it from its support bar and hang it on the graph at its corresponding period. Remind the students that the actual length of the pendulum is measured from the pivot to the center of gravity of the bob. When using rings for bobs, the center of gravity is at the center of the ring, therefore it is important that the centers of the rings be lined up on the horizontal axis. By using this self graphing technique, it is not necessary for the students to measure the pendulum's length and the effect of the length of the pendulum on the period is shown quite dramatically.

Once all groups have added their pendulums to the graph discuss the results. The graph should look like a y-parabola. If it is not obvious that it is a parabola remember that the origin is a point on the graph - zero length will have zero period. With a marker sketch the curve on the graph. Discuss with the students the shape of the graph and what it represents mathematically. Hopefully they will come up with the idea that there is a direct relationship between the length and the square of the period. (This depends on their level of math ability.) If this relationship is not obvious, lead the students by a discussion of what needs to be done to straighten out the graph. This approach usually gets to the idea of squaring the period. The students should now verify these predictions by squaring their period and regraphing on the second end roll graph. The students should transfer their pendulums from the first to the second graph. The resulting graph should be a straight line through the origin. At this point the class can discuss the results that the square of the period is directly proportional to the length of the pendulum. This would be a good point to start a discussion of the equation and theory of a pendulum.

Conclusion:

This activity will take more than the usual lab period. A good breaking point would be after finding the effect of the bob and the amplitude. This activity can be used with elementary students up to the first graph.

Evaluation:

The student's understanding of this material can be evaluated by having them use the graph to predict what the period of a pendulum will be for a specific length. They can then experimentally verify their prediction.

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Inertia

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Objective:

The idea is if enough demonstrations of inertia are done, the definition or meaning of inertia will become clear.

Here is a list of the things I did, what I used, and how I did them.

1. Tablecloth and Dishes

Get heavy dishes from garage sales or resale stores. Fill glasses 3/4 with water. Use red dye to make "wine".

Use a cloth that has no hem on the side you are pulling under the dishes. Pull down, not back, on the cloth. Try to have all dishes within 12 inches of the far edge of the table, and no dishes near your end.

2. Eggs and Water Glasses

I used 3 eggs, 3 pieces of mailing tube (or paper towel tubes) cut down, a metal pie plate, 3 glasses of water, and a broom.

The trick is to hit the metal plate with the broom squarely (not up or down), and snap the plate out so that the eggs fall into the glasses of water. The eggs need to be EXACTLY above the water. Wide glasses help.

3. Glasses and Blocks (Samuri Scientists)

Get 5 SMOOTH blocks stacked on top of each other, and put a glass of water on top. Get something heavy to knock the bottom block out.

4. Coin on Pool Balls

Lay a pool ball on a round filter paper, or somehow outline a circle around the ball. Balance a quarter on the pool ball. Hit the pool ball with another cue ball, and try to knock the quarter outside the circle. You can cheat by making the target ball a little heavier that the cue ball.

5. Ken and Barbie

Strap Barbie into a skate or small car, and leave Ken balanced on top. Run them into a wall and watch Ken fly out.

6. $20.00 Bill and Two Wine Bottles

Fill two wine bottles with water. With one bottle standing upright, lay the bill across the neck opening, and then balance the other bottle upside down on top of the first bottle. The idea is to pull the bill out without spilling any water. Holding the bill tautly with one hand, use your other hand to hit the bill in a quick downward motion in order to pull it out.

7. Hoop and Ring

Balance a hoop in the opening of a bottle, and then balance a piece of chalk on top of the hoop. Get the chalk right over the neck of the bottle. Then whip out the hoop and the chalk will drop into the bottle.

These activities have a lot of excitement and a pretty high failure rate. It's a good idea to let a student try to do the activity after you do it, to show them how it is done. A failure is almost as much fun as a success.

The general conclusion from our class was:

All heavy objects seem to have a "lag time" before they get moving (or in the case of Ken, before they stop). The heavier the object is, the greater the lag time. This is inertia.

Then John said:

"An object at rest will stay at rest, and an object in motion will stay in motion in a straight line unless an unbalanced force acts on it."

We decided John was unbalanced and we went back to our original conclusion.

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Rockets

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Objective:

This miniteach is designed for grades 3-8. The student will be able to design or build their own rocket.

Materials Needed:

Materials listed are for groups of five.
rocket kits
ditto paper
tape
glue gun
3/4 in. dowel rod
corrugated paper
ruler
scissors
1 in. coffee straw
engine
hanger
recovery wadding

Strategy:

The students will construct the model rocket.

1. Buy the model rocket kits and engines.

2. Read the instructions carefully and construct the model rockets.

3. Attach the engine as directed to the bottom of the rocket.

4. Ignite the engine with the jumper cables that will be connected to the battery of a car or buy the electrical launch controller and launch pad.

5. Your model rocket should be in flight.

The students will now build their own rocket.

1. You roll up a sheet of ditto paper the same diameter of the 3/4 in. dowel rod and tape it.

2. Glue and slide in the 3/4 in. dowel rod about 2 in. inside the rocket tube.

3. Cut out three fins for the rocket in the corrugated paper (3 in. x 1 in.). Make sure the fins are the same size.

4. Attach the fins to the rocket with glue about 3/4 in. apart and symmetrical around the rocket.

5. Attach the coffee straw, which is the launch lug, in between the fins about 2 1/2 in. from the bottom of the rocket.

6. Make a cone with a piece of ditto paper about 2 in. diameter for the nose of your rocket.

7. Crumple and insert the recovery wadding and tape on the nose cone.

8. Prepare the engine and read the instructions very carefully.

9. Prepare to launch your rocket.

Performance Assessment:

To complete the building of the rocket. The rocket should successfully launch and be in flight.

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Weightlessness

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Objectives:

Mass remains constant but weight is the force with which the earth pulls the body to itself. Weight is felt by the support given to us by the floor. Weightlessness is a result of free fall. Orbital motion is a form of free fall.

Materials Needed:

analytical balance(1), pliers, string; teddy bear and ball; styrofoam cup, water. For each pair of students: 1 styrofoam cup, rubber bands, 2 weights, such as washers and 1 paper clip.

Strategy:

The concepts of mass and weight are first elicited from students and an acceptable definition written on the board. An analytical balance is displayed and with a nutcracker in the left pan. Discussion is generated as to how mass can be measured on it and what would happen to the balance if the nutcracker were to "lose" weight. Now a thread is used to connect one leg of the nutcracker to the top of the balance and the pans are still balanced. "If the thread were burnt now," says the teacher, "would the pans still balance? Why or why not?" The experiment is promptly performed and results discussed. The teacher holds a large spring balance and has students read the weight of an object. Now he/she jumps to the floor and students discuss why the scale reading decreased to nearly zero.

Students are given their equipment and escorted to the stairwell so that one partner lets drop the cup with the weights suspended outside it by the rubber bands. The other partner at the bottom notes the position of the weights and when the "jump" occurred. Now the teacher shows a styrofoam cup with 2 holes bored in the sides near the bottom. The cup is filled with water. With the holes plugged by the fingers, the cup is dropped. The class observes that as long as the cup falls, no water spills out.

Now the teacher holds teddy and the ball on the same level and lets them fall simultaneously. Students observe that they fall together and hit the ground at the same time.

Performance Assessment:

Back in their seats, the teacher asks the following:
1) What happened to the falling weights? Why did they jump into the cups? By comparison with the falling spring scale what must the weights have been experiencing?
2) Why did the water not spill out of the falling cup? Would the fact of its feeling "weightless" explain why it exerted no pressure on the holes? When did the water spill out?
3) In what way is this experience similar to that of a passenger in an elevator

whose cable has been cut?
Is gravity not acting anymore on the person? How can we tell? Then gravity is not the reason for weightlessness, but the falling away at the same rate of the elevator.

4) How do we normally experience weight?
5) When teddy and ball fall, what fact gives teddy the illusion that he is floating? What gives orbiting astronauts this sensation?

Conclusions:

During free fall; the pliers, the spring scale, the weights and the water were experiencing weightlessness though gravity's force was still acting on them all. If their motion were suddenly stopped, their full weight would seem to return because their supports were pressing upwards into them.

In the freely- falling elevator, a scale placed under the person's feet falls away as fast as the person himself, the scale would read zero and the person feels weightless.

Persons in orbital motion are in free-fall. That's why they experience weightlessness.

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Simple Machines

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Objectives:

This lesson was designed for students in grades 2-4.
The students will be able to identify the six simple machines and how they are used in our lives. They will gain a basic understanding of the use of force and effort.

Materials Needed:

For Inclined Plane - Weights (identical for each group), Spring scales, Ramps (cardboard, approximately 5"x30")

For Wedge - Child's ax, "Blocks" of cardboard (use masking tape to tape together 8 4" squares of cardboard to form a block, simulating a wood block), 2" bolts with hex heads, 2" nails with large heads, Pencils, Hand-held pencil sharpeners, Iced oatmeal cookies, Oranges, Plastic knives

For Screw - Pencils, Paper triangle shapes (8" long), 2" screws, "Blocks" of cardboard

For Lever - 3 stuffed teddy bears (2 the same size and 1 much larger), Cement block or wood block , Tongue depressors, Pencils, Sugar cubes or mini-marshmallows, Child's toys (rakes, shovels, hoes, wheelbarrow, broom, Nerf Bat, Nerf Football, canoe and oar)

For Wheel and Axle - Small child's bike (just the front wheel and handlebars will do), Large teddy bear, Large photos of Ferris Wheel, Merry-Go-Round (child's toys work very well), Screwdrivers, 2" screws, "Blocks" of cardboard

For Pulley - Small Kermit the Frog doll, Flagpole about 3' high with fixed pulley and flag, Gallows-type contraption with fixed pulley at top, movable pulley suspending weight at bottom, Spring scale, Snow White doll, Model of well with fixed pulley

Strategy:

Inclined Plane - Draw 2 identical houses on board, except one house has a ramp to get to the door, and the other has stairs. Discuss the houses, and have the children tell you that the house with the ramp probably has a person in a wheelchair living there. Discuss whether it is easier to lift that person straight up to the door or to use the ramp. Use the cardboard ramps to demonstrate the wheelchair ramp in the house. Measure the effort that you need to lift a weight straight up to the height of 12", then measure the effort that you need to pull the same weight up the ramp. Determine which method required less effort. (Be sure to clarify the word plane as a multi-meaning word, since we are not referring to an airplane.) Elicit from the children other examples they may have seen of inclined planes.

Wedge - Display the child's ax and reference it to the tools the settlers and Indians used in "Pocahontas" or the woodcutter's ax in "Little Red Riding Hood". Help the children to describe the ax as being a triangle or a wedge shape.

Distribute a cardboard block, bolt, and nail to each group. Ask the children to compare the bottom of the bolt and the nail, then to compare the effort required to push each into the block.

Distribute a pencil to each child. Ask them to sharpen the pencils without any help. Distribute the sharpeners, have the children observe the edge of the sharpener is a very sharp wedge, then allow them to use the sharpeners to sharpen the pencils. Elicit from the children other examples of wedges they may have seen.

Distribute a plastic knife and either an iced oatmeal cookie or an orange to each student. Ask them to pretend they are very young and have no teeth, so they will have to keep their lips curled around their teeth. Then have them try to eat their cookie or orange without using teeth or fingernails. Have them look at their knife and determine that the knife is a wedge they can use to peel the orange or cut the cookie. Finally, have the students feel their teeth and determine that they are sharp and also function as a wedge they can use to cut the cookie or peel the orange.

Screw - Ask the children to wind the paper triangle around their pencil (so that it looks like a screw). Compare the screw to the nail and the bolt and then ask the children to use their fingers to put the screw into the cardboard block. The children should be able to recognize that a screw is actually an inclined plane wound around. Elicit from the children places that they have seen screws used, such as drills, etc.

Lever - Set up a see-saw with a board and a cement block. Have the two small teddy bears "play" on the see-saw, then have the large bear come to "play". When he jumps on one side of the see-saw, one of the small bears will fly off. Ask the children why this happened and they should indicate that the large bear was too big and/or he ran and jumped with too much force. Define the see-saw as a lever, and point out that a lever has to have 3 components - a fulcrum, a load, and a force.

Distribute a tongue depressor, pencil, and several sugar cubes or mini-marshmallows to each child. Have the children make their own see-saws. They may experiment with moving the fulcrum (pencil) and the amount of force which they apply to the load.

Ask for volunteers to come forward to demonstrate how "Old McDonald" used tools like shovels, hoes, rakes, wheelbarrows. (Sing "Old McDonald".) Ask for a volunteer to demonstrate the use of a broom. Ask for a volunteer to demonstrate use of the bat and ball. (Sing "Take Me Out to the Ball Game.) Ask for a volunteer to demonstrate use of the football. (Sing "Bear Down Chicago Bears".) Display the toy canoe and oar and demonstrate their use. The children should be able to indicate that all of the toys from this demonstration are examples of levers.

Wheel and Axle - Display the front wheel and pedals from a child's tricycle. Help the teddy bear ride the bike. Demonstrate how the pedals (axle) turn the wheel so that the wheel can travel a great distance. Explain how a ferris wheel and a merry-go-round function as wheels and axles.

Distribute the screwdrivers, screws, and cardboard blocks. Have the children use their screwdriver to put the screw into the cardboard block. Explain that a screwdriver is a wheel and axle, with the wheel turning the axle and increasing the force applied. Try to elicit from the children the understanding that a doorknob is another example of a wheel and axle.

Pulley - Display the flagpole and tell the children that Kermit has a job to do - raise the flag! His problem is that he cannot jump to the top of the flagpole to pull the flag up. He finally tries pulling on the rope, which will raise the flag. Have the children observe that Kermit pulled down, but the flag went up, so a "fixed" pulley changes the direction of force. (Be sure to clarify for the children that "fixed" is a multi-meaning word, meaning stationary, not the opposite of broken.)

Use the gallows contraption to illustrate the use of a movable pulley. Determine the force necessary to raise a wooden block, then compare that to the force necessary to raise the block using the movable pulley. The children will be able to see that a movable pulley reduces effort.

Stand Snow White at the well. Tell the children that Snow White has to work very hard for the wicked Queen. One of her jobs is to bring water from the well every day. Demonstrate that Snow White uses a pulley to help her bring up water.

Performance Assessment:

In each example of a simple machine, the children should be able to explain how the machine helped to reduce effort, increase force, or change the direction of force. They should be able to give several examples of simple machines they see and use every day.

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Vectors

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Objective:

The student is introduced to the concept that both magnitude and direction are necessary when giving instructions for locating a place. Modifications of this material make it suitable for grades three through twelve.

Materials Needed:

Map transparencies------Chicago Loop, School neighborhood, I.I.T. campus, Cartesian graph paper
Chalk board
Meter stick

Suggested Strategy:

Activity 1. Using the Chicago Loop transparency, the class is invited to take an architectural tour of the Loop. We meet in front of Sears Tower and I inquire as to the route that must be taken to reach the Civic Opera House. The student who answers must give both the number of blocks and the direction. The next step is to go to the chalk board and draw, using arrows whose lengths represents the number of blocks and whose tips point in the correct direction, the route to be taken. This process is repeated for several different locations in the Loop.

Activity 2. Students are shown a map of the I.I.T. campus on the Overhead projector. After dividing the class into groups of two, they are given different locations to find on the campus. The unit of distance chosen for this exercise was the pace. Upon returning to the classroom, each group had to draw on the chalk board their route using vectors. In addition, they had to change their pace unit of distance into meters.

Scalars:

Objective:

To enable students to become familiar with the concept that certain numbers have only magnitude.

Equipment:

Room transparency
Overhead projector pen
Thermometers

Suggested Strategy:

Activity: Students are located near windows, doors and at varying heights throughout the room. Their task is to take and record the temperature at their location. After five minutes, each person goes to the chalk board where the projected image of the room appears and records the results.

The class then analyses the temperature distribution field that they produced. Places of approximately equal temperature are connected. The result is called a temperature field and the lines are called isotherms. A two day sequence of weather maps enable the class to see the movement of hot air across the country.

Performance Assessment:

Both classroom demonstrations and student participation provided varied approaches to understanding.

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Inertia

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Objective:

This lesson is for primary students. The main objective of this mini-teach is for students to learn and understand what inertia is. They will learn the difference between inertia for objects at rest and objects moving in a straight line.

Materials Needed:

Two dolls (Barbie & Ken), two carts (skates, skate board)

Strategy:

Place one doll in each cart. Secure one doll with a rubber band, tape or string. Push the carts into a wall. Ask the students what happened and why. (Doll not secured should fly out or fall forward). Talk about seat belts.

Materials Needed:

Two identical coffee cans and a hammer.

Strategy:

Fill one of the cans with a mass (a piece of metal) that will stay in place. Keep top opening of the cans away from the class when placing them on top of table or smooth surface floor. Tap one can lightly with the hammer, and ask students to keep their eyes on the can. Next tap the second can with the hammer, ask the students to watch that can and ask them which can rolled the farthest ... why? (The can with the mass will not go as far as the empty can because the full can has a lot of inertia and tends to stay at rest).

Materials Needed:

A 2 X 4 block of wood, a dowel & a hammer

Strategy:

Drill a hole the diameter of the dowel through the block of wood. Insert the dowel loosely into the block and hold the block precariously suspended. Hit the top of the dowel with the hammer. You will drive the dowel through the block, but the block of wood will not move since its inertia will try to keep it in place, even though that place happens to be in mid air.

Materials Needed:

Large size textbook & friction beads

Strategy:

Place a book on top of a large size desk top. Give the book a thrust with one hand and see how far the book will slide across the desk top. Next sprinkle beads on desk top then place the book on the top of the beads, now see how far the book will slide across the desk top. The book has inertia in each case and tend to keep moving. The reason the book stops in one case is friction.

Materials Needed:

A three foot length of dowel & a 2 X 5 board

Strategy:

Drill a hole the diameter of the dowel in the board. Cone shape one end of the dowel. Place the dowel on the floor with the flat end of the stick (dowel) on the floor. Next place the board on the cone end of the stick until at rest. Raise the stick into the air and pound stick heavily onto the floor. The board should slide to bottom of stick until it hits the floor...why? (because of the inertia in the board.)

Materials Needed:

Three 3 X 5" boards & a hammer

Strategy:

Stack the boards on top of each other. Hit the bottom board horizontally with the hammer. Watch the two boards on top drop into place. Repeat the process with the second board and watch the top board drop into place.

Materials Needed:

Felt or cloth table cloth
8 Meter sticks
4 Clamps
2 Pool Balls
1 Pool cue (wood dowel)
1 One marker & a quarter

Strategy:

Stretch out the table cloth taut and pin it down with the meter sticks and clamps. Put an eight inch circle in the center and another 14 inch circle around the eight inch one.

Place the pool ball in the center with a quarter on top of it. Challenge the students to knock the quarter outside the small circle. Students may not hit the quarter with the pool ball they are shooting at it, and they may not start closer than the large circle.

Materials Needed:

A 5-gallon bottle, crochet hoop & ink pen with a flat top

Strategy:

Place the bottle on a table top. Next balance hoop on bottle top then balance pen on top of hoop. Snatch the hoop from the inside real fast and watch the pen drop into the bottle. The only force acting on the pen is gravity which pulls it straight down.

Performance Assessment:

Students' performance assessment will be measured by their participation and interest in each activity followed by a test on inertia. The students will leave the class with a through understanding of Newton's first Law of Motion.

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Torque

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Objectives:

This assignment will be for 6th grade students. The main objective of this mini-teach is to show the difference between Work and Torque, in relationship to Force and Distance.

Materials Needed:

1. A Jensen balance bar with ten 50 gram weights.
2. A Torque bar with a 500g weight.
3. A wooden wheel with four nuts and bolts drilled in it.

Strategy:

1. The students are given the weight and distance on the left side of the balance bar and asked where to place another weight in order to balance the bar.
2. Give the student the torque bar and a weight. The teacher moves the weights to different positions on the bar. Record the student's observation.
3. Have some students use a small wrench to loosen 2 bolts and other students use a large wrench to loosen 2 bolts. Record the observations. Discuss the ratio between amount of force and the length of the wrench. (The longer the wrench, the less force required to loosen the bolts.)

Performance Assessment:

Assessment will be based on the following:

1. The teacher will put a weight on the balance bar at a specific location and give the student a weight. The student will be asked to balance the bar by choosing the appropriate location on the bar.
2. Torque worksheet with the formula, (T = D x F).
3. The student will explain why the larger wrench loosens the nut with less force than the smaller wrench.

Conclusions:

1. The torque on both sides of a Jensen Arm, when the bar is balanced, will be equal.
2. The bar will require more force in order to hold it horizontally as the weight is moved away from the handle. (It will feel "heavier", but it is the SAME MASS, only in a different location. It requires MORE FORCE, but is no heavier.)
3. The larger wrench will remove the nuts with less force than the smaller wrench. (D x f = d x F) (The large wrench, a BIG DISTANCE times a small force is equal to a small distance times a BIG FORCE, the small wrench.)
4. The difference between torque and work is the concept of rotation. Torque

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is work (distance times force) which causes rotation.
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Give Me Energy

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Objectives:

The 7th and 8th grade students will be able to define, give examples of, and differentiate between potential and kinetic energy.

Materials Needed:

per group for Lab 1
roller skate
wide, flat board (ramp)
spring scale
2 blocks of wood
some form of weight to be added to the skate
meter stick
log sheets with charts to record data

The Lesson:

Begin by asking the students to find what the following 3 things they see have in common.

Show them:
1. an electric cord
2. a can of Mountain Dew
3. a person climbing up a ladder

Leave the three displayed throughout the lesson. Tell them **at the end of the lesson** and after they have shared their hypotheses that each of the three give something energy.

Strategy:

Hypothetical Situation:

I was camping one day, and I was given the responsibility of starting the fire. As I went out searching for fire wood, I found a terrific small log! It was perfect with the exception that it was too long. I needed to break it. (Bring out a thick and long piece of wood and demonstrate an attempt to brace the wood, step on it, and show the board would not break.) Can anyone give me suggestions as to how I can improve my potential to break my log? (List all answers on board for later reference.)

Do LAB #1:

Directions for the student:

1. Make a ramp with a block of wood and a wide flat board. Measure the height of the ramp. Mass a roller skate with a spring scale and record that data. Place the skate at the top of the ramp and release it. Measure how far the skate rolled, from the bottom of the ramp to the rear wheel of the skate.
2. Raise the ramp by adding another block under the long board. Measure and

record the new height. Repeat the process of rolling the skate and measuring the distance it rolled. Record results.

3. Add weight to the skate. Measure and record the new mass of the skate. Repeat the process again of rolling the skate down the ramp at each of the two heights and measuring the distance it rolled. Record results.
4. Study the results and draw a conclusion.
   *Can you give inanimate objects energy?
   *Did the skate have more energy at any one time?
   *How did YOU give that skate more energy?

****

Return to the hypothetical situation and discuss why adding weight or height will give you potential energy to break your "log." Discuss formula of:
gravitational Potential Energy = Weight x Height

Stand on a rung of a ladder. Ask "How can I increase my potential energy?" Discuss other forms of potential energy: a bow and arrow with the bow pulled back, a skydiver in an airplane, a spring compressed,...
Game: In teams of three, and in 5 minutes, come up with as many examples of potential energy as your team can. Your team will receive one point for each example that no other team thought of, so be creative!

"As I fall off this ladder, I lose potential energy, right? Where does it go? What about that Law of Conservation of Energy?" Discuss and define kinetic energy. As a class, give examples such as a book falling, water tumbling over a water fall, a fist swinging in the air, a baseball player sliding in to home.

Materials Needed:

per group for lab 2
1 full pop can
1 empty pop can
1 ramp
3 blocks of wood
3 cereal boxes or cornstarch boxes
log pages for results

Do LAB #2: BOX BOWLING

The goal of this lab is to knock over the empty cardboard boxes, i.e. **accomplish WORK.** (Remember work is defined as a force applied through distance.) From the discussion of kinetic energy get the students to remind you that kinetic energy is the energy of motion used to do work. Ask the students to try different things to do the MOST possible work (knock over as many boxes as possible).
Rules of the lab:
1. All work must be done by a rolling can.
2. Can must be LET GO, not pushed or pulled.
3. Record every attempt you made and the data you measured.

****

Finish by comparing the results of all the groups. Give them the formula for kinetic energy:
KE = 1/2 x mass x velocity^2

Knowing this formula, discuss which makes a greater impact on the amount of kinetic energy, increasing the mass or increasing the velocity. (Answer: increasing the velocity).

Performance Assessment:

The students will receive points based on demonstrated effort, care in measuring results and recording data, and logical and complete support for the conclusions they claim to be true. The students will also be asked to give a VISUAL example of both potential and kinetic energy and explain the difference between the two.

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Newton's Third Law of Motion

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Objectives:

This lesson is for 7th and 8th graders.
Students will be able to do activities to demonstrate Newton's Third Law of Motion.
Students will be able to explain Newton's law.

Materials Needed:

1. dynamic carts
2. 100g weights-6
3. spring balances-3
4. fish line
5. rope
6. clamps-4
7. pulleys-2
8. meters sticks-10
9. scissors,tape,paper
10. blueprint of rocket

Strategies:

Using the PHENOMENOLOGICAL approach, the teacher demonstrates Newton's Third Law of Motion by placing a firecracker between two pop cans and lighting it. Also a student is used to demonstrate force by having the student press against a wall (action) and the wall presses against the student (reaction). Also the teacher pushes down on the student's arm (action) and the student's arm moves upward.

Students move to the various stations to do the activities.
Station 1-Balloon Race
A fish line is extended from two ring stands for the race. The students use tape to attach the balloons to the straw. The fish line is pushed or threaded through the straw. The balloon(s) is/are blown-up and the end is pinched or closed. The students release the balloons. The air comes out the end of the balloon (action) and the balloon moves forward (reaction). The distance traveled is measured in meters.

Station 2-Spring Balances and Weights.
A demonstration of equal force being exerted on a spring balance is set-up for the students. There are two 200g weights attached to each end of the balance. The students are asked to guess the weight on the balance. Later the students will vary the number of weight and check the reading on the balance to see if the amount of force is the same (equal). The weights are pulling downward on the balance scale (action) and the scale is pulling on the weights (reaction).

Station 3-Dynamic Carts
Two carts are placed end to end and a trigger is released where one cart hits

the second cart (action) and the second cart moves backward (reaction). Both carts move backward equal distances because the masses are the same. However, if the masses are varied 2x, 3x or 4x, the students will get some interesting results about the distance that each cart will travel.

Station 4-Roller Skates
Two students, both on roller skates, will pull on a rope and the other students will observe which student moves the greater distance.

Station 5-Rocket Launching
Using blueprints, the students make rockets for launching. The pieces are put together with tape. The rockets are launched by using a straw to blow into the open end.

Conclusions:

1. Students will discover that the activities dealt with forces.
2. Students will discover that the two forces, action and reaction, are equal in magnitude and opposite in direction.
3. The student will discover that the motion of the forces must be in a straight line.
4. Students would have discovered Newton's Third Law of Motion using the PHENOMENOLOGICAL approach.

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Pendulums

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Objectives:

The students will be able to determine what factors effect the period (time to swing back and forth) of a Pendulum. I use this for my sophomores in high school but don't let that fool you. This can be used at any level where students can count to twenty and time something.

Materials Needed:

pins
various lengths of string
washers (or any of various weights to hang)
clock with second hand (or anything to time with)
a long piece of cardboard or cork-board with a number-line marking off every five seconds for up to one hundred seconds

Strategy:

Tell the students to grab a length of string, tie a washer to one end and a loop at the other end of the string. Next have the students time the period of twenty swings. Have the students hang their washer at the spot on the number line that corresponds with the time they have found. There should be a pattern that looks something like this:

```
      | |  |  | | | ||
      O O  |  | | | ||
           |  | | | ||
           O  | | | ||
              | | | ||
              O | | ||
                | | ||
                | | ||
                O | ||
                  O ||
                    ||
                    ||
                    O|
                     O
```

Ask the students what factors would affect the period of the swing. With encouragement, I bet they'll come up with length of string, mass, amplitude (how wide an arc), whether the hand moves or not, and possiblely some others. Break the students up into groups and have each group investigate these factors by keeping all factors constant except the one they are investigating. Have each group report back to the class with their findings.

Performance Assessment:

The verbal report to the group may be graded. I believe the ideas of particular interest include whether or not the group controlled the variables, did they actually make accurate measurements and present the data (not just guess or approximate) and then the actual presentation.

Conclusions:

1. Mass of the hanging objects does NOT make a difference.
2. The amplitude does NOT make a difference (for amplitudes less than 40 degrees).
3. Length of the string DOES make a difference. There is a formula if you wish to check it. (Period=2(3.14)Square-root(Length/gravity) or T=2pi*sqrt(l/g))
4. Small hand movements do not make a difference extreme hand movements will.

Reference:

Me! Call me anytime for help.

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Bouncing Balls

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Objective:

The student will make careful observations of a ball bouncing off a hard surface one time or sequentially for several trials, to study how the ball travels as it bounces across the room. From these observations, he/she will then be able to describe and explain the motion of the ball.

Materials Needed:

1. A box containing several small super balls, medium-sized super balls, hollow rubber balls, solid rubber balls, tennis balls, golf balls, baseballs, and whatever other types of balls are available.

2. Several meter sticks for measuring the height of the bouncing ball.

3. Several smooth hard flat horizontal surfaces suitable for bouncing balls---floors, lab tables, sidewalks, and the like.

Strategy:

The initial phase of the activity involves making careful, qualitative observations of a single bounce. Next, the students in teams should take a ball and measure quantitatively how high it bounces when dropped from a given height. Then the various types of balls are categorized as to how well they bounce. Finally, one should consider the same ball bouncing several times and study the progressive decrease in the heights to which it goes.

A. Procedures for qualitative study:

Bounce a ball a number of times off the table or desk in front of the class, catching it on first bounce, and ask students to describe carefully what they see. Make a list of the qualitative observations---a list of typical observations is given below:

1. The ball is released from rest and picks up speed until it hits the surface and bounces off.

2. After bouncing off the surface the ball comes back up to a height which is less than the height at which it started, before stopping to climb.

3. The higher the distance from which the ball is dropped, the higher it will bounce.

4. The ball makes very brief contact with the table, seeming to leave it almost instantaneously.

5. The ball makes a sound when it hits the table, which changes with the height from which it is dropped.

6. The ball may bounce differently when it hits different points on the table.

B. Procedures for quantitative study:

1. Each student should be given a ball to drop from a height **h** of one meter and measure the distance **d** to which it bounces upward. The results should be arranged according to the types of balls and the group should discuss which balls bounce well, and why.

2. Each student should release the ball from several heights [**h** = 50 cm, 75 cm, 100 cm, 125 cm, 150 cm, etc] and measure the distance **d** to which it bounces. The ratio **d/h**, which we call the elasticity coefficient, should be roughly the same for each height.

3. If there is time, a given ball should be allowed to bounce several times after being released from an initial height **h**. The sequence of bounce heights, d_1, d_2, d_3, ..., should be measured. Each time the bounce height reduces by roughly the same factor, the coefficient of restitution:

$$d_1/h = d_2/d_1 = d_3/d_2 = \ldots$$

The ball begins at rest from height **h** with potential energy **mgh**, where **m** is its mass and **g** is the acceleration due to gravity. On first bounce it comes up to a height **d**, corresponding to potential energy **mgd**. The coefficient of restitution, **d/h**, is the fraction of mechanical energy remaining after first bounce.

Energy is dissipated in the form of heat and acoustical energy. Physicists believe in the principle of conservation of energy as a consequence of the symmetry of the basic interaction under translations in the time coordinate.

Performance Assessment:

Bounce a ball across the room to an assistant so that it strikes the floor several times. Have each student draw the trajectory of the ball in the notebook, describing its motion as completely as possible.

Conclusions:

A ball bounced off a hard surface loses a specific fraction of its mechanical energy with each bounce.

Multicultural:

The bouncing of a ball on a hard surface is essential for an understanding of baseball, which is played with gusto in Asia, Latin America, the Caribbean Region, and North America. English Cricket [played throughout the British Commonwealth Nations] requires similar knowledge of the physics of bouncing objects.

The deep connection between symmetries and conservation laws was first understood by the Mathematical Physicist **Amelia Emmy Noether** [1882 - 1935].

References:

Robert K. Adair, **The Physics of Baseball**, 2nd edition [Harper 1994].
ISBN 0-060095047-1.

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Friction - What a Drag

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Objectives:

At the end of this lab students will be able to:

1) recognize that weight and surface type affect friction.
2) recognize that surface area does NOT affect the friction.
3) control variables
4) Recognize that some things are hard to measure like friction because the spring scale needle vibrates.

Materials Needed:

4 wood blocks for each lab group (approximately 2 inches x 3 inches x 6 inches is a good size because then the ratio of areas of the different sides is simple-6 sq. inches by 12 sq. inches by 24 sq. inches).

Small screw hooks that can be screwed into the blocks to hook the blocks together.

1 spring scale for each group (if spring scales are not available you may substitute a rubber band and note the amount the rubber band stretches).

Different surfaces like a table, carpet, glass, etc.

Strategy:

Ask the students what factors they think affect the size of the frictional force. Give the students the equipment and let them try various combinations. At this point DON'T TELL THE STUDENTS WHAT COMBINATIONS TO TRY. Let them explore combinations such as a different sides, different surfaces areas, a train (one hooked after the other), stacking on top, or combinations thereof. Regroup the students together as a whole class after approximately 15 minutes of experimentation to discuss preliminary results. At this point you can remind students to control variables, remind them that they should not pull the spring scale at an angle and that the different sides of the block might have a different grain which can affect results. Let the students go back into their groups so that they can fine tune their results. Have one representative from each group make a brief, final presentation of their results.

Performance Assessment:

Each group can be assessed informally by the lab work they do. I award extra points for each clever idea I see. The presentation can also be used to determine that they have the correct concepts. Also good questions to ask are:

1. What happens if I double the weight by stacking one block on top of the other? Answer: The frictional force doubles.

2. What happens if I keep the weight the same but double the surface area? Answer: The frictional force stays the same.

3. What happens if I double the surface area and double the weight? Answer: The frictional force is doubled (the increase in weight doubles the force and the surface area has no effect).

4. How does the surface type affect the frictional force? Answer: The answers will vary. Typically the smoother the surface is the less friction. However, sometimes glass which is very smooth will produce a large frictional force, specifically if it is very clean. FYI: There is a weak vacuum that is formed that pulls the blocks together when there is little or no air between the surfaces.

Conclusions:

The frictional force is affected by the surface type and weight. It is not affected by the surface area.

Evaluation:

See performance assessment.

References:

1. Almost any general physics book will give you information.

2. Me- Give me a call.

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Momentum Conserved

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Objectives:

The students will apply two of Newton's Laws of Motion discovering that Momentum is conserved.

Materials:

- Newton's Cradle
- Carts
- Planks with skates screwed to the bottom
- "Crash Dummy Motorcycle"

Strategy:

NEWTON'S CRADLE--Collision
Pull one ball out. Ask "What will happen when I let go?" Let everyone contribute. Then let go. See what actually happens. Do not get into a big discussion at this point! Come back to this at the end.

TWO CART COLLISION--
Define Momentum: Mass x Velocity. Have two carts of equal mass collide with each other from opposite directions. Ask "What happened?" Let everyone contribute. (Newton III, and Momentum is Conserved)
Then have the two carts collide when one of the carts is the same mass as previously and the other has a third cart stacked on top-a larger mass. Ask "What happens?" Let everyone contribute. (still Newton III, also Newton II, Momentum is Conserved)

PLANK WITH ROLLER SKATES ATTACHED--
Have a student walk the plank. Ask "What happened?" (Plank goes the other way.) Let every student contribute. Have students of different weights take turns. Observe any difference this makes. (Newton III, Momentum is Conserved)

CRASH DUMMY MOTORCYCLE--
Construct a "Wall" at the end of an inclined plane. Have the motorcycle with the dummy rider crash into the wall. Ask "What happened?" (Newton III, also Newton I, Momentum is Conserved)

NEWTON'S CRADLE REVISITED--
Go back to the Newton's Cradle. Again pull out one ball. Let go. Ask "What happened?" and "Why?" Students should be able to discuss the results in terms of Newton's Laws for each ball's collision with the next ball. They should also recognize that Momentum is Conserved in each collision. Now try this with two, three, or even four balls. They should be able to extend their conclusions to these unequal mass collisions.

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Momentum And Colliding Spheres

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Objective:

Student will be able to understand that mass x velocity equals momentum.
Student will be able to understand the impacts of collisions and their results.
Student will be able to determine the vector of an incident.

Materials:

Paper, Chalk, Iron Spheres, Marker, Meter Sticks, and String.

Strategy:

The student is asked to think about the content of an object. The student will probably think in terms of the object's weight. The student will learn that weight is the force upon a body due to gravity and that force is usually a push or a pull. Mass is introduced to the student. The student will learn that mass is the quantity of matter in a body. A rolling sphere is shown to class. The student learns that its mass is the matter that makes up this object. After rolling the sphere across a table, the student is asked what happened? At this point velocity is introduced. The student learns that velocity is the specification of the speed of a body and its direction of motion.

The student is told that when we think of mass and velocity together, we call this action momentum. The student learns that momentum is the idea of inertia in motion. Momentum refers to moving things, that is, the mass of an object multiplied by its velocity. Two spheres are shown with the same amount of mass. The student is asked what would happen if both spheres were moving at the same speed toward a wall? At this point, the student is asked what would happen if the two spheres were moving toward each other at the same speed? The teacher advises that when two objects with the same mass are moving toward each other at the same speed and hit each other, we call this activity a collision. We say that both objects had the same momentum and at impact their momentum has been shared equally.

At this point, the teacher demonstrates a collision using spheres of equal mass. The spheres are hung from a ceiling and paper is placed underneath. One sphere is stationary while the second sphere is held at a short distance. The student is asked what will happen when the two spheres collide? The student will give a variety of responses yet the idea of both spheres colliding and being held as they reach their peak in flight will be emphasized. The teacher demonstrates a few trial collisions and tells the student to place an X at the point of release of the moving sphere. An X is also placed at the point of the stationary sphere. The sphere is released and collides with the stationary sphere. Both spheres are caught at their peaks and arrows are placed at each point. The word Vector is written on the board and the student is told that the momentum of each sphere can be expressed involving a technique called vector addition. The student learns that the magnitude of the sphere and its direction are the two elements used to find net momentum. Using a meter stick, the released point is measured to the stationary point. Next, the two points at the sphere's peak are measured. Using meter sticks to draw the lines at a right angle, a parallelogram is drawn. The released point to the stationary point should equal the stationary point to the end of parallelogram after drawing a diagonal line.

The student is asked to start at a given point and walk in one direction counting ten steps. He walks in a second direction and counts ten steps. The student is asked how many steps would it take to return to the starting point. The student will probably feel that if he adds ten plus ten, then the correct answer will be twenty. The student is told that the diagonal line to the starting point is usually greater. After a few trial runs the student learns that although the sides of a figure are equal, the diagonal point to the starting point is usually greater. A second demonstration is given using spheres of unequal mass. The stationary sphere is one half the mass of the moving sphere. After the collision and after the parallelogram is made, the student is told to take one half the length of the sides of the parallelogram due to the unequal mass. Afterwards the student will determine that the distance from the release point to the impact point should equal the distance from the impact point to the length of the diagonal line.

Summary:

The understanding of momentum should help the student in preparing for additional activities in PHYSICS. To introduce the meaning of inertia at the beginning of a momentum lesson is helpful. The student learns the meaning of force and is introduced to mass. The next step is to define velocity and share that momentum is mass multiplied by velocity. Hands on activities are excellent ways to help the student see the reality of what is happening. After vector addition is introduced the student is helped to recognized points of importance. The release point, the impact point and the peak points are placed with an X so the student can recall distance recognition. In conclusion, the student is helped to developed a parallelogram. This method of discovery and development should encourage the student to continue his interest in Science activities.

References:

Hewitt, G. Paul, **Conceptual Physics** : Momentum. Little, Brown and Company Boston, Mass. Fifth Edition.

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Straight Line Motion with a Stomper

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Objectives:

After this experience, the student should

1. be able to define average speed (distance traveled/time)
2. be able to graph distance vs time and velocity vs time
3. be able to find the velocity from the distance time graph (slope)
4. be able to find the acceleration from the velocity time graph (slope)
5. recognize constant velocity, constant acceleration and changing acceleration from the shape of the distance-time and velocity-time graphs

Materials needed:

(for each group)
Stopwatch, meter stick, Stomper (battery powered toy car), large washer or 100 g mass, tape, paper tape (ticker tape) and a recording (ticker tape) timer, Tricycle (optional).

Strategy:

Part I: Begin with the Stomper. Show it going in a straight line along the counter top. Ask: How fast is it going? What do we need to know to find out? (You need a distance traveled and a time.) Give each group a Stomper, stopwatch and meter stick. They should determine the average speed of their Stomper. It should take 10 or 15 minutes for them to do several trials.

Part II: How fast was the Stomper going as it moved along? Was it going the same speed everywhere or did it speed up or slow down? Point out: The stopwatch is only good for substantial times, several seconds. It will not help us answer this question. Demonstrate the recording timer by pulling a meter or so of tape through it. Explain why the time intervals are equal and ask why the spaces are not even. (The spaces are small where the speed was small.)

Each group should do two runs with the Stomper pulling a length of ticker tape behind it. Mark off each tape in groups of six dots. (Each six is one tenth of a second.) The first tape will become a distance-time graph. Rip each six dot section and glue it to a piece of graph paper. The first section goes on next to the origin. The second section goes over one width of tape, but starts up, so that its bottom is next to the first tapes' top. The third goes over one and its bottom lines up with the top of the second section, etc. Thus the vertical axis is the distance traveled in cm. and the horizontal axis is the time in tenths of a second. This graph will have a constant slope equal to the average speed found with the stopwatch. Demonstrate how to find slope.

The second tape will become a velocity-time graph. Each six dot section is the distance traveled per tenth of a second, so it is the average velocity for that tenth of a second. For this graph the vertical axis is the velocity in cm per tenth of a second, while the horizontal axis is again the time in tenths of a second. For this graph, each tape has its bottom on the horizontal axis. The tapes go next to each other in order. This graph will have a slope very close to zero because the speed is very close to being constant. How did this velocity compare to the slope of the first graph? How did it compare to the speed found with the stopwatch?

Be certain that you ask the students to describe each of these two graphs and to compare them to each other.

This is probably as much as you can expect for one day. I would then spend a day or so doing constant velocity problems to reinforce this concept.

Part III: Constant Acceleration

Drop a mass. (Catch it!) Ask if this is constant velocity. Ask how you can find out. Using the recording timers, attach the tape to the mass and drop the mass over the side of the table. (It pays to protect the floor with a book, or a newspaper.) Run two tapes. Mark every sixth dot and create a distance-time and a velocity-time graph. Look at them! The distance graph will **not** be a straight line this time. It should look like a parabola, because the speed is increasing, the slope will increase. The velocity graph **will** be a straight line, but will not be horizontal, because the speed is increasing at a constant rate. The slope of this line is the acceleration. (The change in velocity/the time it took (dV/dt).)

Again, it is very important to ask what these graphs look like and to compare them to each other and to the graphs from Part II.

This is probably a second day's work. It should be followed by problems with distance, velocity and constant acceleration.

Part IV: Constantly Increasing Acceleration

Lay a chain on the counter top. Push it over the edge one link at a time, until it goes by itself. Ask what kind of motion this is. Again, we can analyze this motion if we attach a tape to it. Mark every sixth dot. The distance time graph is optional, be sure to do a velocity time graph. This will not be a straight line because the velocity increases at an increasing rate. (The acceleration (slope) increases at a constant rate, thus we get a parabola.)

It is once more imperative that you ask the students to describe the shape of the graph(s) and compare them to the previous graphs.

Optional: Have Tricycle races. Have someone ride a tricycle pulling ticker tape. The velocity-time graph is the most interesting. Be sure to ask about the accelerations. They will be positive and negative!

Conclusions:

Velocity is the distance traveled/time it took (dD/dt)
Velocity is the slope of a distance-time graph
Acceleration is the change in velocity/time it took (dV/dt)
Acceleration is the slope of a velocity-time graph
Constant velocity gives straight line graphs for both d-t and v-t
Constant acceleration gives parabolas for d-t, but straight lines for v-t
Changing acceleration gives v-t graphs with changing slopes

Performance Assessment:

Using TWO SPEED Racer (a friction car, about $2.75 at "Toys R Us"): Show it to the students. Placing it on a flat surface, where all of them can watch it, pull it back until you hear a click. Let it go. It will go in a straight line, and suddenly increase its speed.

Ask the students to sketch two graphs. A Distance vs Time and a Velocity vs Time graph.

Rubric:

5 pts Graphs are correctly labeled on each axis. Distance-time graph shows as short straight line, sloping up followed by a steeper straight line; also sloping up.
Velocity-time graph shows a short, horizontal line, followed by a higher horizontal line.
4 pts Graphs not correctly labeled, but show the proper shapes.
3 pts Graphs not correctly labeled, and only one of the graphs shows the proper shape.
2 pts Graphs properly labeled, but neither graph is the proper shape.
0 pt No labels, and wrong shapes.

Multicultural Applications:

There are many applications of distance vs time in life including the Summer Olympics track competitions and the speed skating and cross country skiing in the Winter Olympics.

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Periodic Motion - The Pendulum

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Objectives:

To introduce the concept of periodic motion and relate it to the movement of a pendulum. To discover that the period of a pendulum is dependent on the length of the pendulum and independent of the bob and the amplitude.

Materials needed:

Each group needs a stop watch and pendulum with a different bob.

Materials for pendulum -
string
bob - infant stacking rings provide colorful bobs of different sizes and mass
right angle clamp
ringstand
rod

For class graphs - two pieces of end roll paper approximately 21/2 meters long, a meter stick, markers and masking tape

Strategy:

Begin the class period with a discussion of what the students think periodic motion is. After a few minutes, bring out a pendulum from behind the lab table and use it as an example of periodic motion. Point out its various parts - bob, length, pivot point. Demonstrate what is meant by period and amplitude. Spend a few minutes discussing the accuracy of measuring a single period. The students should realize that timing how long it takes for ten cycles and dividing by 10 will lessen the effects of reaction time and result in a more accurate measurement of the period.

Break up the class into groups. Each group is given a pendulum with a different bob but all pendulums are 1 meter in length. (A different option would be to have the students construct their own pendulums 1 meter in length. If doing so, make sure to discuss that the length of the pendulum is measured from the pivot point to the center of gravity of the pendulum bob.) Each group is to find the period of their pendulum by timing it for 10 cycles and using an amplitude of 10 cm. After doing so, they are to experiment with other amplitudes (5 cm, 15 cm, 20 cm, etc.) to determine if the amplitude effects the period. All groups record their data in the class data table on the board under the following headings: Color of bob, Time for 10 cycles, Period, Effect of changing the amplitude.

When all groups have recorded their data, call the class together for a discussion of the results. It should be apparent that the shape and mass of the bob and the amplitude have no effect on the period. Small differences can be explained by experimental error. If the students are not sure that the rings are actually different masses, bring out a scale and prove it. If you are using infant stacking rings, there will be about a 50% difference between the largest and smallest ring's mass.

Each group is given a different length of string to create a new pendulum. Lengths should vary from 25 cm to 2 m. As before the groups will find the period of their pendulum. This time they will graph their results on a length versus period graph.

While the students are finding the period of their pendulums, hang a piece of end roll paper about 21/2 meters long on a wall and label the axes. The vertical axis is marked off to the actual length of the pendulum. The horizontal axis is the period marked in a convenient scale.

When the students have found the period of their pendulum they should remove it from its support bar and hang it on the graph at its corresponding period. Remind the students that the actual length of the pendulum is measured from the pivot to the center of gravity of the bob. When using rings for bobs, the center of gravity is at the center of the ring, therefore it is important that the centers of the rings be lined up on the horizontal axis. By using this self graphing technique, it is not necessary for the students to measure the pendulum's length and the effect of the length of the pendulum on the period is shown quite dramatically.

Once all groups have added their pendulums to the graph discuss the results. The graph should look like a y-parabola. If it is not obvious that it is a parabola remember that the origin is a point on the graph - zero length will have zero period. With a marker sketch the curve on the graph. Discuss with the students the shape of the graph and what it represents mathematically. Hopefully they will come up with the idea that there is a direct relationship between the length and the square of the period. (This depends on their level of math ability.) If this relationship is not obvious, lead the students by a discussion of what needs to be done to straighten out the graph. This approach usually gets to the idea of squaring the period. The students should now verify these predictions by squaring their period and regraphing on the second end roll graph. The students should transfer their pendulums from the first to the second graph. The resulting graph should be a straight line through the origin. At this point the class can discuss the results that the square of the period is directly proportional to the length of the pendulum. This would be a good point to start a discussion of the equation and theory of a pendulum.

Conclusion:

This activity will take more than the usual lab period. A good breaking point would be after finding the effect of the bob and the amplitude. This activity can be used with elementary students up to the first graph.

Evaluation:

The student's understanding of this material can be evaluated by having them use the graph to predict what the period of a pendulum will be for a specific length. They can then experimentally verify their prediction.

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Why Use Seat Belts?

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Objective:

To show some reasons for wearing seat belts.

Materials:

Per Group:

- Board (for ramp - length about .75 m to 1.0 m)
- Dynamics cart
- Books (for propping up one end of board + 1 for barrier)
- Clamp (to fasten barrier down to table top)
- Plasticene (or modeling clay)
- Meter stick or ruler

For Teacher Demonstration:

- Barbie doll or similar type doll
- A seat and dash assembly

Strategies:

Number 1: Teacher Activity

As a demonstration, put a Barbie doll on a block seat on a dynamics cart. Place the cart at the top of a ramp which is set with the top 30 cm above the table top. Clamp a book down as a barricade about 50 cm from the bottom of the ramp. Release the cart and observe where the doll ends up after hitting the barricade.

Number 2: Student Activity

Mark the ramp into 20 cm intervals. Raise one end of the ramp about 30 cm. Position an obstacle such as a book about 30 cm from the bottom of the ramp. Hold the obstacle stationary.

Make a plasticene (modeling clay) cube "passenger" with sides about 2 cm long. Place the passenger on the front of a dynamics cart. Place the front of the dynamics cart at the 20 cm mark on the ramp. (It may make results more graphic if students shape the plasticene into a roughly human shape.)

Release the cart. Observe the motion of the passenger during and after the collision. Measure the distance the passenger moves from the collision point to where it stops. Repeat this step several times and average the distance.

Release the cart from several different distances up the incline to vary the speed. Observe the motion of the passenger and measure the distance as in the previous paragraph. Repeat this procedure several times for each measured 20 cm mark to average the distances.

Possible Extensions:

By spending some money at your local Venture or similar store, you can obtain some "Crash Dummies" and a "Crash Dummy Car." They claim to have a "Crash Dummy Cycle" as well. The car has a facility built in for attaching seat belts. It also gives a very satisfactory crash in that the roof and windshield and front wheels go flying off. If the dummies hit hard enough, they may also fly apart. Students should also get a thrill from this.

Another extension would be to use ticker tape timers and attach ticker tape to each dummy as well as the car. This would provide a difference in time of movement as well as distance differences.

Performance Assessment:

(The following questions should be made available. If students have trouble with the questions, the equipment should still be available. They should obtain their equipment again and do what is needed in order to answer the questions.)

1. Describe the motion of the passenger during and after the front-end collision.

2. How did the speed just before the collision change as the cart was released from further up the ramp?

3. How did the distance the passenger rolled after the collision change as the cart was released from further up the ramp?

4. Describe the motion of an unbelted passenger in a car which collides with a stationary obstacle.

5. Draw a diagram of the forces acting on the cart and on the passenger on the flat before and during collision.

6. Seatbelts prevent a passenger from being thrown from the car. Why is it usually more dangerous to be thrown from the car than to remain in it?

7. Newton's First Law says (in essence), it takes an unbalanced force to change velocity. Explain how this applies to the motion of the passenger during the collision.

Multi-Cultural Implications:

The implications of this laboratory experiment tend to be related to age rather than culture. My observation tends to the idea that mature individuals use seatbelts more than teenagers do. However, European countries do not have speed limits on their highways. Therefore, the Europeans do wear seat belts more than Americans do!

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Reaction Time

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Objective:

Each student will be able to obtain his/her reaction time by making simple measurements. Each student will also be able to find the constituent parts of their overall reaction time.

Materials needed:

Each group of two will need one 30 cm (12 inch) ruler to find their reaction time. For the more advanced activities, each group will need a meter stick, a stopwatch and two funnels connected together by more than two meters of rubber hose.

Suggested Strategy:

The time that it takes you to react to a particular situation is called your reaction time. Your reaction time depends on many factors including the stimulus and the particular part of the body that is to react, i.e., it takes longer to move your foot from the gas to the brake pedal than it does for your fingers to grab something simply because your leg is heavier and it has to move farther.

Today we will be finding the time required for you to grab a dropped object, namely a 12 inch ruler. Brace your hand on the edge of a desk so that the fingers are over the edge ready to grab the ruler as it is dropped. Have your partner hold the ruler such that its zero centimeter mark is even with the center of your fingers and, at some random time, drop it. Record the distance that the ruler fell (where you caught it), during the time that your body was reacting. Do this at least 10 times. It is **important** that the ruler is held **even with** your fingers (not above or below them) and that it is **dropped** (not thrown down). **ALL** readings **MUST** be recorded but any readings that are way out of line can be crossed out and ignored. (In general, your measurements should be between 10cm and 30cm.) Average your readings and then determine your reaction time.

The reaction time can be determined in several ways. You can use the standard equation for freely falling bodies
$S_f=1/2at^2+v_ot+S_o$. Where S_f is the average
distance that the ruler fell, a is the acceleration of gravity (980 cm/sec^2), t is the time that it takes the ruler to fall (the reaction time), v_o is the initial velocity (zero) and S_o is the initial distance (zero). Substituting in zero for v_o and S_o simplifies this to
$S_f=1/2at^2$. Solving this equation for t
yields

$$dt=sqrt(2S_f/a)$$

An alternate method would be to use the following chart to look up the time corresponding to the average distance that the ruler fell.

DISTANCE (cm)	TIME (sec)	DISTANCE (cm)	TIME (sec)	DISTANCE (cm)	TIME (sec)	DISTANCE (cm)	TIME (sec)
0.012 --	0.005	8.281 --	0.130	31.862 --	0.255	70.756 --	0.380
0.049 --	0.010	8.930 --	0.135	33.124 --	0.260	72.630 --	0.385
0.110 --	0.015	9.604 --	0.140	34.410 --	0.265	74.529 --	0.390
0.196 --	0.020	10.302 --	0.145	35.721 --	0.270	76.452 --	0.395
0.306 --	0.025	11.025 --	0.150	37.056 --	0.275	78.400 --	0.400
0.441 --	0.030	11.772 --	0.155	38.416 --	0.280	80.372 --	0.405
0.600 --	0.035	12.544 --	0.160	39.800 --	0.285	82.369 --	0.410
0.784 --	0.040	13.340 --	0.165	41.209 --	0.290	84.390 --	0.415
0.992 --	0.045	14.161 --	0.170	42.642 --	0.295	86.436 --	0.420
1.225 --	0.050	15.006 --	0.175	44.100 --	0.300	88.506 --	0.425
1.482 --	0.055	15.876 --	0.180	45.582 --	0.305	90.601 --	0.430
1.764 --	0.060	16.770 --	0.185	47.089 --	0.310	92.720 --	0.435
2.070 --	0.065	17.689 --	0.190	48.620 --	0.315	94.864 --	0.440
2.401 --	0.070	18.632 --	0.195	50.176 --	0.320	97.032 --	0.445
2.756 --	0.075	19.600 --	0.200	51.756 --	0.325	99.225 --	0.450
3.136 --	0.080	20.592 --	0.205	53.361 --	0.330	101.442 --	0.455
3.540 --	0.085	21.609 --	0.210	54.990 --	0.335	103.684 --	0.460
3.969 --	0.090	22.650 --	0.215	56.644 --	0.340	105.950 --	0.465
4.422 --	0.095	23.716 --	0.220	58.322 --	0.345	108.241 --	0.470
4.900 --	0.100	24.806 --	0.225	60.025 --	0.350	110.556 --	0.475
5.402 --	0.105	25.921 --	0.230	61.752 --	0.355	112.896 --	0.480
5.929 --	0.110	27.060 --	0.235	63.504 --	0.360	115.260 --	0.485
6.480 --	0.115	28.224 --	0.240	65.280 --	0.365	117.649 --	0.490
7.056 --	0.120	29.412 --	0.245	67.081 --	0.370	120.062 --	0.495

7.656 -- 0.125 30.625 -- 0.250 68.906 -- 0.375 122.500 -- 0.500

Another alternative would be to draw a graph from the above chart and have the students read the time from the graph.

The experiment could be stopped at this point but there are several more things that can be calculated. The time obtained in the first part (call it reaction time-t_r) is really the sum of three other times: 1) the time that it takes for your brain to realize that the object has been dropped (call it processing time-t_p); 2) the time for the nerve signal to travel from your brain to your fingers (call it nerve time-t_n); and 3) the time that it takes for your fingers to close (call this dynamic time-t_d). (i.e., $t_r=t_p+t_n+t_d$)

The easiest of the three to calculate is the nerve time (t_n). Since nerve signals travel at an approximate speed of 30,000 cm/sec, we can measure the distance from your brain to your fingers and use the equation time=distance/rate to find the nerve time.

The next easiest is dynamic time (t_d). Dynamic time can be found by timing 25 **complete** pinches (open and close) and then dividing that time by 50 (since each open and close is two actions).

Processing time (t_p) can be found two ways. One method is to work backwards from the reaction time. Given t_r, t_n and t_d, you can subtract the sum of t_n and t_d from t_r to get the processing time.

Performance Assessment:

Several large sheets of paper should be hung on the wall of the classroom about knee level. Each sheet should have the outline of a gas pedal and brake pedal drawn on the sheet. Each group of students should be able to determine their reaction time and dynamic time for moving their foot off of the gas to the brake.

Multicultural Note:

All of the equations and symbols used in this lesson are the same, regardless of the language of instruction. Ukranian, German, Italian and Japanese physics books all have their physics equations in 'English'.

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Projectile Motion

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Objective:

As a result of this experience students will:

1. be able to recognize that projectile motion is the resultant of two independent velocities, horizontal and vertical.
2. determine which angle of launch for a projectile will yield the greatest range.
3. realize that the greater the angle of launch, the greater the vertical velocity component.

Materials:

For each group: 2 pieces of foam board 90 cm. x 50 cm., Sheet of paper 70 cm.x 70 cm., Tape, Meter Stick, 4 different colored markers, Angle launcher, Spring.

Strategy:

Roll a ball across the table. Ask the students to define this motion. Throw a ball straight up into the air. Ask the students to define this motion. Using the responses, establish that both objects follow a straight line path, but that one path is in a vertical direction and the other is in the horizontal direction.

Next, have a student throw a ball across the room into a garbage can held by another waist high. Instruct the students to watch carefully and repeat this 2 times. Ask students to write down how they would define this motion, under the heading Day 1 on their record sheet. Collect these Pre-Activity student responses and read some out loud.

Set the stage for the activity by pointing out that they will be investigating how the parabolic path of a projectile is formed. Hand out instructions and let the groups work together for about 20 min.

....DAY 1.... INSTRUCTIONS PART 1

1. Tape a large blank 50 cm. x 50 cm. paper to the table.
2. Draw a 40 cm. line straight up the paper about 4 cm. away from the vertical edge of the paper.
3. Draw another 40 cm. line across the paper about 4 cm. away from the horizontal edge of the paper.
4. Extend the lines so that they meet at one point in the left hand corner.
5. Next, measure about 4 cm. starting from the corner where the lines meet, up along the vertical line and mark it with a dot. This will be the starting point for the vertical foamboard.
6. Repeat step 5 for the horizontal axis.
7. Line up one piece of foamboard so that the bottom edge of the foamboard lies just above the horizontal line on your paper. Guide this board along the horizontal line until it's vertical edge is on the horizontal starting dot. BE SURE the entire bottom is just above the horizontal line and the vertical edge begins on the horizontal starting dot.
8. Line up the other piece of foamboard so that the vertical edge lies right next to the vertical line. Guide this board along the vertical edge until the

edge is on the vertical starting dot.
9. Place the marker down at the corner point where the two foamboards meet.
10. Move both foamboards at about the same SLOW speed simultaneously along their respective lines while the marker moves to stay in contact with the moving corner where the foamboards meet, so as to trace a line on the paper of the movement of the corner.
11. Move until both foamboards have reached the end of their lines.
12. Place boards back to their starting points and this time have the vertical foamboard move a little faster than the horizontal foamboard and again trace the path of the moving corner where the boards meet. (use a different color marker)
13. Repeat again, but this time have the vertical foamboard move more slowly than the horizontal board.
14. Write your names on your sheet and return to class.

After 20 minutes:

Have the students tape their data sheets on the board. Note the similarities. Next, use one of the graphs to establish that the path is the result of two independent velocities by drawing the components. Then, hand out instructions for Activity 2 and instruct the students to notice what happens when you change the vertical velocity but keep horizontal velocity constant.

....DAY 2.... INSTRUCTIONS PART 2

1. Get a new sheet of paper and repeat steps #1-7 from Part 1. Redraw the axis with starting dots.
2. Now, mark a line 30 cm. away from the starting dot on the vertical line.
3. Next, line up foamboards as you did in part one steps 7, 8, and 9. For this trial have the vertical and horizontal boards begin at the SAME SPEED, but as the vertical board reaches the 30 cm. mark it should stop and begin to move back to it's original starting dot. During this trial the however, the horizontal board should move the same speed its entire trip.
4. Move the boards back to their starting position and, for this trial, have the vertical board go FASTER than the horizontal board to begin with but have the vertical board slow down, stop at the 30 cm. mark, and then go back down to it's starting mark. (Horizontal should go slow the entire trip.)
5. Repeat, this time have the vertical board go SLOW, come to a complete stop at the 30. cm. mark, and then go back down to it's starting point. Horizontal should go slow the entire trip.
6.Place the names of the students on the sheets and tape them to the blackboard.

After 20 minutes:

Point out similarities between the group graphs. Call attention to the fact that the greatest angle formed by a resultant path was due to a large vertical velocity combined with a small horizontal velocity. Ask the students to guess what angle to shoot a projectile so that it would go the farthest. Record their predictions. Review at this time the sine and cosine trig functions. Remind the students that this case is geometrically similar and review free fall equations. Hand out a worksheet and have the students draw the components of given vectors. Set the stage for the last activity by pointing out to students that to investigate which angle yields the greatest range they must keep the initial velocity of the projectile the same in each case.

.....DAY 3.... INSTRUCTIONS PART 3

1. Hold a meter stick against the wall. Mark a 1 meter mark with tape and then measure up 2 more m. and mark with tape.
2. Stretch a spring on a meter stick, hold it parallel to the wall and then shoot the spring straight up. Do this several times until you can repeat a shot to go exactly 2 m. several times. Write down how far you stretched the spring. Get an assigned angle for your launch from your teacher. (TEACHER: assign 15º, 30º, 45º)
3. Calculate the speed at which the spring is fired, use the equation

$v^2 = 2\ ad$.

4. Determine the vertical and horizontal components of the original velocity by using v_v= v sin(angle) and v_h = v cos(angle)

5. Use the vertical velocity to find the flight time, $t = 2v_v/a$.

6. Use the flight time and the horizontal velocity to calculate the range $d=v_h t_f$

7. Measure off this distance and shoot the spring using the same stretch.

Performance Assessment:

BEFORE the instruction begins have the students answer:
1. If a baseball player throws the ball as hard as he can, and wants it to go as far as possible, should he throw at an angle to the ground >45,<45 or = 45 ?
AFTER Instruction:
2. The human cannonball is shot at a 30 degree angle with a velocity of 10 m./sec. Determine where they should place the net to catch him.
3. The following is a strobe picture of the human cannonball's ride. At the spots marked, draw the vertical and horizontal components of velocity.
4. Assuming that the initial velocities of the missiles are the same, draw the paths of missiles shot at the following angles: 15^o, 30^o, 45^o, 60^o.

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Sports in Physics: Measuring Velocity in a Mini-Olympics

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Objectives:

1. To demonstrate an understanding of the difference between speed, velocity, and acceleration.
2. To compute velocity.
3. To compute acceleration.
4. To read and construct a line graph and a bar graph that show information about velocities of sports activities.

Materials Needed:

(for each group)
Two stop watches, one meter stick or tape, roll of masking tape or chalk, notebook paper, pen, calculator (optional)
(for teacher)
Five-minute video of Olympic competition, bulletin board with pictures of multi-cultural sports activities, chalkboard for graphs or three pre-printed graph poster boards, sports vocabulary in Spanish and English (sports-deportes) (velocity-velocidad) (speedometer-cuentakilometros) (at full speed-a toda velocidad) (Olympic-Olimpico)

Suggested Strategy:

1. Introduce topic with a five-minute video of Olympic events or with pictures of a variety of sports.
2. Involve pupils in a discussion about motion. Ask what we usually notice about motion: how fast something is moving and in what direction something is moving.
3. Guide pupils in a question/answer session which leads them to define speed (rate at which something moves), velocity (speed plus direction), and acceleration (rate of change of velocity).
4. Explain formula for computing velocity (velocity=distance divided by time).
5. Explain formula for computing acceleration (acceleration=(V_2 - V_1) divided by T_2).
6. Divide the class into groups of four or five, distribute materials, assign an area on a playground or in a gymnasium for competition.
7. Establish rules for performing at least 3 competitive events in which velocity can be measured (running, walking, pushing a ping-pong ball with your nose, riding a bicycle, crawling, etc.).
8. Give each group a chart for recording data (names of participants, activities, distance covered, time). Decide on the unit of measure.
9. Have the pupils place all results on a master chart:
   NAME ACTIVITY DISTANCE TIME VELOCITY (ft/s or m/s)
10. Transfer results from the master chart to a large chalkboard graph:
    a. Let x = one activity
    b. Let . = the second activity
    c. Let o = the third activity, etc.

11. Have the pupils connect the lines of the line graph. Ask questions about the results.
12. Have the pupils of each group compute the group average for each activity.
13. Transfer the group average for each activity to a bar graph.

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      |
      |
      |
   V  |
 (m/s)|
      |
      +----------------------------------------------------
  (Examples)  Walk  Run  Ride      Walk  Run  Ride
                   JETS                 ROCKETS
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14. Re-explain the formula for computation of acceleration.
15. Have the groups return to the game area, perform one activity and compute acceleration.
16. Transfer the group averages to another bar graph.
17. Lead the pupils in a discussion to summarize the results of the Mini-Olympics.

Performance Assessment:

You and your friends are visiting a park for the day. On a small sign, you read that park officials are offering a $100 prize to the person who can design a one-hour mini-sports competition, complete with a description of the prizes to be awarded to individuals or teams who reach the highest VELOCITIES.

You immediately decide to win the $100. In at least two paragraphs, describe the activities, materials needed, method and unit of measure, distance to be covered; and tell how you will plot the results.

Rubric:

1. Five points = A complete description, including each item listed in the performance assessment
2. Four points = Partial description, with at least one activity, unit of measure, time and/or distance, and one formula
3. Three points = Partial description, with at least one activity, unit of measure, and one formula
4. Two points = Little or no description, with at least one activity
5. One point = Description unclear
6. Zero = No attempt

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So You Want to Hit a Home Run?

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Objectives:

1. Students will demonstrate a relationship between the position of the baseball bat and the baseball at the point of contact to direct the ball in the appropriate hitting field.
2. Students will determine the center of percussion and the center of mass for a baseball bat.
3. Students will analyze the projectile motion of the path taken by a baseball as it is thrown in the air as well as the projectile motion of the path taken by a tossed bat that is made to flip over itself while in flight.
4. Students will find the center of mass for several irregularly shaped objects and relate this concept to the playing of sports in general.

Materials needed:

Per Lab Group:
Baseball bat, meterstick, string, push pin, two transparencies, weighted object, tape (masking or colored), Baseball (or substitute tennis ball for safety purposes), flat board slightly larger than the width of a baseball bat, flat irregularly shaped object (cut from styrofoam, manila folders, or any material that is relatively stiff)

Per Class:
Video camera, blank video tape
Video tape of portions of a baseball game
VCR with slow motion or frame by frame motion

Strategy:

Begin lesson with a video of portions of a baseball game that involve pitching, strike outs, fly balls to each field, bunts, home runs, line drives, and foul tipped balls. Ask students to watch for physical factors that are involved in the playing of the game of baseball. Make a list of these observations on the chalkboard. Encourage a discussion of how physics is related to baseball. The focus of the lesson will be on batting.

Investigation #1 Ball and Bat Contact
Use a flat board instead of a bat for this portion. (A flat board is used to concentrate on the angle of the bat and to eliminate human errors and skills that influence what is observed.) Students toss the ball at the board while the board is held at different angles. Students record their observation of how the ball rebounds off the board in a data table that includes these types of hits: infield fly, fly ball to each field, ground ball, line drive, foul ball- left or right, foul tipped ball almost straight up. Drawing diagrams of the angles and paths may be helpful in the data chart.

Investigation #2 Get to Know Your Bat
Hold the bat gently from the handle so that the bat hangs downward. Tap the ball all along the edge of the bat from top to bottom. (There is one spot on

the bat that sounds and feels more solid.) Mark this spot with tape.

Investigation #3 The Sweet Spot

Hold the bat horizontally and firmly from the handle. Drop the ball from a height of about 10 cm above the bat so that the ball hits the bat and bounces off. Do this for about 5 to 10 different places on the bat, making sure to include the spot that was taped in investigation number 2. Graph the height the ball bounces vs. the position on the bat. (The ball bounces highest at the marked spot. The marked spot is called the sweet spot by baseball players and the center of percussion by scientists.) To illustrate the center of percussion and its importance to the baseball player suspend a meterstick by a string from a small hole drilled in one end. For a uniform meterstick, the center of mass should be at the 50 cm mark and the center of percussion should be roughly 20 cm below the center. Hit the meterstick at various locations to try to cause the meterstick to swing. (At the center of percussion, the meterstick swings in a wide arc with very little rotation about the vertical axis. At other points on the meterstick, the meterstick wobbles, twists, and vibrates quite a bit more. If the ball contacts the bat at the sweet spot most of the energy from the bat is transferred to the ball in the forward direction since energy is not lost due to rotational motion. The batter's hands sting less since the bat was not caused to vibrate.)

Investigation #4 Balance Your Bat

Balance the bat horizontally on one finger. Mark this spot with a piece of contrasting tape. (This place is the center of gravity for the object. For most objects this place is also the center of mass.)

Investigation #5 Toss Your Bat and Ball

In front of a video camera, toss the ball in the air so that it travels in an arc for a horizontal distance of about 5 meters. Still in front of the video camera, toss the bat so that it flips over itself as it travels, in an arc again about 5 meters horizontally. Students should describe in as much detail as possible the two motions observed. (A good taping of the motion is important here. Choose a uniform background that will provide contrast. Do not move the camera with the motion, instead focus on a central point of the background. It may take some practice to make sure the entire path is recorded in the space allowed.)

Investigation #6 Analysis of the Paths of the Tossed Bat and Ball

Tape a transparency to the TV screen. Play the tape the students made in slow motion or frame by frame. Students plot on the transparency the piece of tape that marks the center of mass for the bat as they see its position on the TV screen. Do the same for the position of the ball as it crosses the screen. (Both paths plotted should be the typical parabolic shape of a projectile. This could be done as a class with a few students helping with the plotting, however it is better to allow each group to plot their own segment. Investigations #7 and #8 may be done during this time by other groups who are not working with the VCR. The centers of mass for any object will follow a parabolic shape regardless of the motion of other parts of the object.)

Investigation #7 The Center of Mass for Irregularly Shaped Objects

Using string and push pins, suspend the irregularly shaped object from a point near the edge. A weighted string hangs from the point of suspension. Students draw the line formed by the string on the object. Several points of suspension are chosen. (The vertical line passing through the point of support must also pass through the center of gravity. Since the center of gravity and the center of mass are at the same location, the intersection of several of the points will determine the center of mass.)

Investigation #8 People Have Centers of Mass, Too

Stand against a wall so that the heels, legs, and back are all touching the wall. Try to touch your toes so that the heels and legs are still touching the wall. (As the student leans forward the majority of his/her center of gravity is no longer over his/her feet, therefore the student will fall before touching the toes.)

Performance Assessment:

1. Give students a few shapes, both regularly shaped and irregularly shaped. Have a dot somewhere within the shape, some shapes may have the dot at the center of mass while others should not. Tell students that the dot represents the center of mass for the shapes. Ask the students the following questions: Do you agree or disagree with the placement of the dot to represent the center of mass? Why or why not? What might you do to prove yourself correct in each case? Why would your method work?
2. Make or buy a ball that has an off-centered weight in it. (The "GUAC" ball) Toss a ball, and the weighted ball in the air. Ask students to observe the two motions. Are the paths what you would expect? Explain and justify your answer.
3. Sometimes when hitting a baseball, a batter's hands will sting. What is causing the sting? Why is the sting not present every time the batter contacts the ball?

Scoring Rubric:
5 points: Answers correctly with clear, sound, multi-faceted, logical arguments (diagrams, examples, sketches, etc.)
4 points: Answers correctly with clear explanation
3 points: Answers correctly but reasons unclearly
2 points: Partially correct with effort toward explanations
1 point: Answers with no supporting evidence
0 points: Answers of "I don't know"

Conclusions:

Center of gravity is an important concept used in sports, not just baseball. A player cannot balance if the center of gravity is not over or under the support base. In sports in which flips and turns of the body are important, such as diving and gymnastics, the athlete's center of mass will still follow a parabolic path while the other portions of the athlete's body will be rotating around this center. An extension of this lesson could be the assignment of individual reports on the origin of several sports that involve projectiles or centers of mass, such as the javelin throw, shot put, discuss, basketball, baseball, darts, diving, gymnastics, golf, archery, the trapeze, juggling, and so forth.

Evaluations:

Discussion of results and discoveries after each investigation seems to be a better method than group discussion at the end of all activities.

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Center of Gravity

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Objective:

Predict and find the center of gravity of an object.

Materials Needed:

2 boxes, string, lead sinker, dissecting needle, metric ruler

Strategy:

A) Use a pair of boxes of the same size for each team of students. If different weights are secured in different places in the boxes, all the teams will find different centers of gravity.

B) Weight half the boxes in advance. Secure the weights with glue. Blocks of wood or metal make excellent weights.

C) Examine an unweighted box.

D) Predict where the center of gravity is.

E) Attach a lead sinker to a 30-cm long piece of string. Tie the string to a dissecting needle. Stick the needle into the broad surface of the box at any point near the edge of the box and mark this point.

F) Let the box and the weighted line hang freely from the needle. With a pencil, mark the position of the weighted line at the edge of the box.

G) Remove the dissecting needle. Use a ruler to draw a line between the two points that you marked.

H) Repeat this procedure for three more points on the surface of the box. Remember to mark each point near the edge of the box. The point at which the four lines cross shows the center of gravity of the box.

I) Examine a weighted box.

J) Predict where the center of gravity is.

K) Repeat steps E through H with the weighted box.

L) Extend your index finger and try to balance each box on your finger.

M) Place each box, with the marked side up, on a flat surface. Spin each box.

Results and Conclusions:

1. How do your predictions compare with the actual location of the center of gravity of each box?

2. How is the center of gravity related to the way each box balances?

3. How is the center of gravity related to the way each box spins?

Summary:

1. Answers will vary.

2. The box balances at the center of gravity.

3. The box spins with the center of gravity as its axis.

Culminating Activity:

1. Clean out an empty soup can or an oat meal box and fully remove both the top and the bottom. Now you have a cylinder.

2. Tape a quarter or some other small weight inside it.

3. Prop up one end of a bread board or some other flat board.

4. Place your cylinder at the low end of the board with the quarter in the two o'clock position. When you release the cylinder, it will roll up the hill.

Summary:

Because its center of gravity is very near the position of the quarter. The center of gravity will go down, causing the cylinder to roll up the hill.

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Friction

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Objectives:

Students will demonstrate a greater understanding of "friction" by cooperatively experiencing and describing a range of phenomena involving friction. Students will understand the term "static friction" and the ratio of friction and weight as it relates to moving an object at rest.

Materials needed:

For each student: wooden sticks, (i.e, popsicle, candied apple and chop sticks)
- one empty thread spool
- metal, plastic, cork and rubber washers
- rubberbands, assorted sizes

For each group: set of slotted weights
- miniature parachutist
- small pan (plastic, from microwave dinners) with a hole for tying the string
- blocks
- spring scale

For teacher's demonstrations:
- Two identical, cylindrical, glass bottles (with tops), filled with various quantities of water
- One wooden slope, at least as wide as the bottles, with sandpaper glued to the reverse side* and two 2" X 4" X 8" blocks
- The teacher wears a pair of jeans with worn knees and a shirt or sweater with worn elbows
- Various surfaces for lunar vehicle runway: smooth, *sandpaper, large frozen tray of ice, carpeting, etc.
- One "slimey" ball
- One crystal wine glass half full of water
- Detergent for washing hands and vinegar
- One spool of thin string
- One pre-made "air car" made from a thread spool, cardboard square and a balloon
- Balloons
- Foam rubber mats of different textures, 24" X 24"
- Column of coins
- Sound tubes

Strategy:

1. Teacher throws a "slimey" ball on the chalkboard and asks students how the ball moves. She rubs an edge of a wine glass to get the glass to sing. She asks the class how it happens. If they don't know, they are told friction did it. Students are asked to rub their hands, then **really** hard, and tell what happens. The teacher rotates the sound tubes so the students can hear and asks the class what makes the sound.

2. Teacher asks students, grouped into cooperative teams, to list examples of friction and then to write a good definition. Answers are written on the board. Class synthesizes answers into one good definition. Students are led to understand that friction can be associated with solids, liquids and gasses and that there are subtle examples as well as flagrant examples. Teacher asks individual students to move a column of coins with one finger on the top of the column. (Teacher demonstrates how to do it: by pressing **hard** on the top coin on the edge closest to her).

3. Students are shown how to make a "lunar vehicle" with the thread spool, various rubberbands, washers and sticks. Students are to predict and/or test-out the best type of components to use which will most effectively use friction to make the vehicle run. Students test their lunar vehicle on various surfaces, i.e., wood, sandpaper, rug, ice and table top. Each group selects its best lunar vehicle to compete with other teams in a race on the indoor/outdoor carpeting.

4. Teacher asks groups to predict what will happen with the two bottles which she is about to let roll down an incline. Students will understand that water creates friction on the glass and slows down and stops that bottle's movement sooner than the empty bottle stops.

5. Teacher asks teams to predict what will happen to the contraption called an "Air Car" when she lets it go. Students will learn that air can reduce friction and overcome gravity.

6. Each group is given a little parachutist, asked to throw him/her into the air, observe and write an explanation as it relates to friction. Each group reads their answer to the class. Students will learn how air can be used to oppose the force of gravity.

7. Groups experiment with various weights and friction using the pan, string, weights, spring scales and various surface textures. The groups are asked to collect data as weight is added to the pan. Students will understand the ratio between weight and the force required to move the weight to overcome static friction, i.e., to move a mass from rest.

Coefficient of Friction: mu = F_{FR}/N

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Circular Motion

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Objective:

Students will be able to recognize centripetal force and discern that radius, mass and period influence this force.

Apparatus:

Group Pack: Centripetal Force Apparatus (Ball point pen tube, string, three 2-holed rubber stopper, butterfly paper clip), 30 metal washers, timer, tape, meter stick.

To Assemble the Centripetal Force Apparatus: Pull the 2 m. string through the empty pen tube until a little over a meter passes through the tube. Next, attach the rubber stopper to one end of the string by pulling it about 15 cm. through one hole, back through the second and fastening the string to the part that enters the first hole. Measure off 1 meter of the string that enters the first hole. Take the other end of the string and attach a paper clip. Measure off 1 meter of string on the apparatus starting from the rubber stopper and ending at the top of the tube that you slid up to the meter mark. Place a piece of tape securely on the string just underneath the other end of the tube. Place the apparatus in a ziplock bag carefully to avoid tangles.

Strategy:

Divide the class into small groups. Give each group a pack. Show students how to get the centripetal force apparatus working by grabbing the pen tube with the rubber stopper at the top with one hand and with the other hand, hold the paper clip tightly. Hold the tube vertically above your head and get the stopper moving in a circle parallel to the floor. Move your hand in smaller and smaller circles until you can keep the ball going in circles by only moving your hand in tiny circles. Establish, through questions and class discussion, that the ball wants to travel in a straight line but it is being pulled back by the string. Illustrate this by letting go of the paper clip and have them observe. Identify this pull of the string on the stopper as a force towards the center or centripetal force. Write the word and its definition on the board.

Instruct students to explore this force by having one student in the group get the apparatus going and then pull the string and the paper clip with 10 washers on it down slowly to see what happens. Ask each group to tell what they discovered. Next, have students measure 30 cm. from the stopper to the top of the tube and then place a piece of tape just under the tube. Have the twirler get the apparatus going and look straight ahead and count the number of times it passes in front of him starting with zero up to 30, making sure to keep the tape just under the tube at all times. Have one student time the 30 revolutions. Have a recorder place the time on the board. As a class, determine the average of all the times. Instruct the students to repeat the above for 60 cm. and 90 cm. Calculate the period for each radius, using the average time in seconds and dividing it by the number of revolutions. Make a class graph of Radius vs. T (period). Summarize with the class that, from the data, the period has a direct relationship to the square of R, or as the radius increases, so does the period; and conversely, as the radius decreases, so does the period.

Next, have students explore what happens to the period when mass increases. Have each group time 30 revolutions of 1 stopper with a 1 meter radius and a constant force of 10 washers. Have each group place time on the board and take the average to calculate the period. Repeat with 2 stoppers and with 3 stoppers. (Attach the stoppers to the first one with more string--be sure to remind students to keep the tape just below the tube.) Plot as a class, mass versus T and summarize the relationship as the mass to the square of the period.

Last, have the students explore what happens to the period when force increases by adding washers to the clip in 5 washer intervals up to 30. Have each group take a timing for each interval of 5 washers while keeping the radius at 1 meter and the mass at 1 stopper and the tape just below the tube. Find the average time. Calculate the period for each 5 washer interval and use the data to plot class graph of Force vs. T (period). Note that the graph reveals that F is inversely related to the square of the period or, as the force increases, the period decreases.

Math: Go over the mathematical derivation of $F = 4pi^2Rm/T^2$

This will take at least 3 class periods.

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Rolling Spheres on Inclined Planes

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Objectives:

The students will be able to determine the distance of a sphere rolling down an inclined plane and discover that inclined planes make work easier.

Materials needed:

4 meter sticks, 1 2.5 cm. steel sphere, 1 metal incline (120 cm. long), 1 short wooden incline (30 cm. long), 4 wooden blocks (4 cm. high) and masking tape

Strategy:

Review what is a simple machine and the types of simple machines. Demonstrate the procedure as follows:

Place the short incline end-to-end with the metal incline, with the short incline on your left.

Place two blocks under the outer end of each incline so that the two inclines look like slides that meet at the bottom.

Tape a meter stick along both sides of the short incline extending from the vertex. Do the same with the metal incline.

Release (do not push) the steel sphere with your fingertip at the 6 cm. mark on the short incline (D1).

Have your partner locate the top point where the sphere rolled and record the number of centimeters the sphere traveled up the metal incline under **Trial 1** for D2 on Table 1 of the Data Sheet.

Repeat the procedure to record **Trial 2** and **Trial 3** from 6 cm.

Calculate and record the average of the three trials under **Average.**

(See the data table on the next page.)

Repeat the same procedure from 12 cm. and 18 cm. to complete the table.

Data Table

D1	**D2 (cm.)**			
(cm.)	**Trial 1**	**Trial 2**	**Trial 3**	**Average**
6				

12					
18					

Conclusion:

The students should notice that as D1 increases D2 will also increase.

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Orbital Motion

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Objectives:

In this activity the students will:

1. compare a circle with an ellipse,
2. communicate an operational definition of an ellipse,
3. understand that as the foci of an ellipse are moved further apart the minor axis becomes shorter,
4. understand that as the foci of an ellipse are moved further apart the major axis becomes longer,
5. communicate a definition of the eccentricity of an ellipse,
6. be able to use a formula to measure the eccentricity of an ellipse,
7. be able to state Kepler's **Law of Elliptical Orbits**,
8. predict the solar energy received at different positions in a planet's orbit.

Vocabulary:

revolve	circle	major axis	ellipse	perihelion
orbit	focus	minor axis	eccentricity	aphelion

Materials Needed:

For each team of two students the following materials are needed:
one foot square foam board, string, thumbtacks, pencils or pens, metric ruler, paper, masking tape or scotch tape, marking pen, data table, graph paper.

Strategy:

Divide the class into pairs.

Activity I Have the students press a thumbtack into point C at the center of the paper where two perpendicular lines intersect. These lines are identified as the major axis (horizontal line) and the minor axis (vertical line). Place a string loop under the tack head and place a pen, point down, inside the loop. Then move the pen outward to stretch the string. The string should stay under the tack head at all times. Hold the pen firmly against the string and move it in a rounded orbit. Paste the completed drawing on the wall.

Activity II Repeat activity I except have the students press a thumbtack 6 cm from the center on each side of C along the major axis. Again, using the pen and the string loop draw a shape. The string should stay under the two tack heads at all times. Paste the completed drawing on the wall.

Activity III Repeat activity II substituting 8 cm on each side of C.

Activity IV Repeat activity II using 10 cm on each side of C.

Activity V Repeat activity II using 13 cm on each side of C.

Complete the data table by measuring and recording the distance between the foci and the length of the minor axis for each shape one through five. Make a bar graph showing the relationship of the distance between the foci and the length of the minor axis for each shape. Discuss Johannes Kepler and his **Law of Elliptical Orbits** which states:

The planets move in orbits which are ellipses and have the sun at one focus. (The other focus is empty).

Discuss the perihelion, the point on the elliptical orbit where the planet is closest to the sun. Discuss the aphelion, the point on the elliptical orbit where the planet is farthest from the sun. Discuss the amount of energy the planets receive from the sun at the perihelion and aphelion.

Hand-Outs:

Worksheets review the concepts of where the aphelion and perihelion are located on the elliptical orbit. They review vocabulary words and use sentence completion to review the concepts learned.

Conclusions:

1. The greater the distance between the foci, the greater the flatness or eccentricity of the ellipse. The eccentricity can be measured by using the formula:

   $$e = \frac{\textbf{distance between foci}}{\text{length of major axis}}$$

   When e=0, the shape is a circle and when e=1.0, the shape is a straight line.
2. The planets move in elliptical shaped orbits with the sun as one focus and the other focus is empty or just a point in space as stated in Kepler's **Law of Elliptical Orbits**.
3. A planet would receive the most amount of heat from the sun at the perihelion which is the point closest to the sun. A planet would receive the least amount of heat from the sun at the aphelion which is the point farthest from the sun.

Evaluation Questions:

l. How many centers were used to draw a circle?
2. How many centers are needed to draw an ellipse?
3. How is an ellipse similar to a circle?
4. How is an ellipse different from a circle?
5. What happens when both foci are placed directly on top of each other?
6. What is the shape of the orbits of the planets?

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Menlo Park, California, l987. pp.59-62.

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Holt, Rinehart & Winston Inc.: New York, New York, l975. pp.43-46.

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Positioning the fulcrum in class one levers

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Objectives:

1. To identify the parts of a class one lever
2. To discover and demonstrate the relationship between force and the distance of the load from the fulcrum
3. To discover that work input = work output with the lever
4. To compute the mechanical advantage of a lever (ratio of the distances through which the forces are exerted)

Materials Needed:

ruler, pencil, 30 pennies, wood block, wood plank (at least 4 feet), bathroom scale, meter stick, various text books

Strategy:

Each group receives the above materials. The group then makes a lever by placing the ruler across the pencil. The pencil (fulcrum) is first placed under the 4 inch mark on the ruler. Ten pennies (load) are placed between the end of the ruler and the one inch mark. Have each group add and record the number of pennies needed on the opposite end of the ruler to lift the ten pennies (load). The experiment is repeated with the ten pennies at one end and the pencil (fulcrum) at the 6 inch and 8 inch marks under the ruler. The groups record the number of pennies needed to lift the ten pennies (load) at the different points of the ruler on the chalkboard chart. The mechanical advantage is worked out using the ratio of the distance of the effort arm to the resistance (load) arm.

Using the discovery of the relationship between the distance of the load to the fulcrum, the groups will lift the teacher (if willing) or a classmate. A wood block and a wooden plank are provided and the class one levers are set up. The student and the textbooks are weighed on the scales and the data recorded. The pupil stands on the load arm and one by one the books are placed on the effort arm until the load arm is raised and the effort arm is touching the floor. Positioning the fulcrum at different points under the plank, find the ratio of the effort arm length to the load arm length to get the highest mechanical advantage. This information is charted on the chalkboard to again note that when the load is placed nearer the fulcrum the effort needed to raise the load is less. Therefore, the longer the distance of the effort arm, the smaller the force needed. The groups then compute work input and work output by using the equation:

$$Fd_{resistence} = fD_{effort}.$$

(where F="load", d=vertical distance "load" is lifted, f="effort", D=vertical distance the "effort" is pulled down) with the data from the chart on the chalkboard. The answer is given in foot-pounds and will indicate that work input is equal to work output.

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Action and Reaction

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Experiment 1

Needed:

One volunteer student

Objective:

To demonstrate that forces occur only in pairs

Strategy:

Have Newton's third law of motion written on the board. Make a brief introduction on Sir Isaac A. Newton and have the whole class read the law.

> Whenever one body (object) exerts a force on a second body (object), the second body (object) exerts an equal and opposite force on the first body (object).

A Handy Hands-on Game

First, extend one hand out and press against the wall. Next, extend hand out in mid air and press. Your body will lean over with nothing to support it. Ask students to explain what happened. Request one volunteer to come to the front of the class. Tell the volunteer that he or she will be your partner in a demonstration to experiment with Newton's third law of motion. Stand facing each other about one arm's length from your partner. The trick is to make your partner move his feet by pushing only on the hands. Each participant should stand with his feet together and one hand behind his back.

Step 1:
You hold up your hand in front of you at shoulder height, palm facing your partner. Tell your partner to push against your hand (you do NOT push back).

Step 2:
Your partner pushes again and you pull your hand back. (Repeat until one partner moves his feet.)

Question: Why do we say that forces occur in pairs?

Answer: Every action has a reaction counterpart (or partner).

continued

Experiment 2

Materials Needed:

1 skate car with propeller fan
6 size C batteries
3 cardboards - sizes: large, medium and small

Objective:

To experiment with the law of action force and reaction force

To sail the skate car or
not to sail the skate car
that is NOT the question!

Question: What do you think would happen if you put various size sailboards on a propelling skate car?

Strategy:

Have class break up into small groups of 3 or 4 members and select a spokesperson. Explain the mechanisms (parts) of the skate car. Demonstrate how the skate car works. Next, hold the large sailboard in front of the skate car approximately 2" away from the fan. Ask students what they think will happen if you turn the fan on. Allow them time to think and discuss the question within each group (approx. 1 or 2 mins.). Regain the students' attention. Ask each spokeperson what her group decided would happen. After all predictions are in, say: "Well, let's put it to the test!" Turn the fan car on while every one observes the results. Ask what happened and why do they think it occurred. Next, put the medium size sail in front of the fan, this time attaching it to the skate car. Ask the groups what they think will happen this time and follow the same procedure. Finally, do the same with the small sail.

Discussion: Newton's third law of motion on action and reaction.

Suggestion:

Put a scoreboard on the chalkboard and select a student to keep score on group predictions.

Example:

The skate car will move	**Right**	**Left**	**Will Not Move**
Group 1			
Group 2			
Group 3			
Group 4			

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Rotational Inertia

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Objective:

To demonstrate how the resistance of an object to rotation is rotational inertia.

Materials Needed:

This list is for a class size of 32 students divided into groups.

4 ramps
4 cans of broth soup covered with paper
4 cans of tomato soup covered with paper
pendulum
hollow wheel
turn table for turning (if possible - optional)
4 meter sticks
8 100 gm weights
masking tape
balance beam and long pole
solid wheel

Strategy:

To begin the lesson, have the students give you several brainstorming definitions of what they think inertia is. Next discuss what they think rotational inertia is and write that on the board. After discussing the vocabulary, have one student from each group sit on the turn table. Spin them slowly. Using equal weights or books in their hands have them pull their hands close to their bodies and then extend them away from their body. As they pull their hands closer to their bodies they will find that they spin faster than they do when their hands are extended outwards. Use this opportunity to discuss how the distribution of mass makes a difference in the rotational inertia.

Next, using your groups, take the 4 meter sticks and tape the 100 gram weights to the bottom of the stick. Put one on each side and tape around it. Have students collect data on who could balance it vertically the longest with the weights on the bottom and again with the weights on the top. Have the students explain why they thought it was easier to balance the weight on the top of the stick versus the bottom. Some will be good both ways but the norm tends to be with the weights on the top.

Using the ramps, have your groups take the soup cans of different contents that are covered with paper and time them as they roll down the ramp. Have them make a graph charting the time it took and the can that won. Have them to try to figure out why one can won over the other. After a thorough discussion, uncover the cans and talk about the contents in the cans and the distribution of the mass.

Now take the balance beam and have it properly mounted with the wooden stands on each end. Have a student walk on the beam with their hands in their pockets, and again with their hands extended holding a long pole or long stick. Talk about which way was easier to walk. Again reinforce that it is easier to balance when the rotational inertia is farther away from the axis.

For some additional fun, make a pendulum and push it back and forth on a long string. Ask the children to tell you how it is moving. Then shorten the string and let them tell you how it is going. Of course the shorter one moves faster because it is closer to the axis. At this point the children can make a pendulum for a hands on activity.

For a final activity take a ring and a solid disk and roll them down a ramp. They do not have to be the same weight or size because the theory will still prove itself. Have the children guess which one will come down first. Explain to them that since the wooden disk is solid, it's mass is closer to the axis than the hollow ring which has all it's mass on the outer rim.

Conclusion:

The conclusion of this lesson would be to have students explain what we did today in all our demonstrations. Ask them to tell you what they liked best and what they liked the least. See if any of your students can think of other examples of rotational inertia that were not used today that can be added to the lesson.

Evaluation:

Often times when we do a lot of hands on activities, we fail to reinforce the comprehension version in writing. My evaluation of this process will be a short quiz that would include all the examples that we had today and to have the children explain them to me. I would also have them draw some of the demos for me on paper so that I know who really was aware of what was happening in the demonstration. I would be looking for 90% accuracy on the quiz.

Summary:

Event	**Results**	
bottles	empty-easy to move	full-hard to move
turntable	mass at center-easy to rotate	mass at edge-harder to do
meter stick	wts on bottom hard to balance	wts on top easy to balance
balance beam	mass at center-easy to fall	mass out-easier to stay
pendulums	short-swings faster	long-swings slower
soup cans	tomato solid-rolls fast	chicken-liquid rolls slower
disk and ring	disk is faster-mass spread uniformly throughout	ring is slower-mass all at the edge (further out)

Reference:

Conceptual Physics - Addison Wesley Paul G. Hewitt 1986 pg 192-204

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Projectile Motion (or You Bet Your Grade)

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Objectives:

To calculate the initial velocity of a spring stretched a varying amount and fired vertically from a shooter and to predict, by calculations, where that spring will land when it is shot horizontally off of a horizontal platform. As a additional objective, to learn that ALL data must be recorded but that data which is way out of the ordinary can be ignored when calculating averages and results.

Materials Needed:

The following materials are needed for each group of 2-4 students:

1) a spring with sufficient elasticity so that stretching it about 1 cm will shoot it to a height of about 50 cm. One end should have a paper clip attached and the other should be bent into a loop which will hook over the nail in the end of the shooter described below (Primary level students might use rubberbands instead but they are not as consistent.)
2) a 'shooter' made from a 1" by 1" by 18" piece of wood with a headless nail driven into the end near the edge so that the spring may be hooked to it
3) several metersticks
4) graph paper
5) a section of a room with sufficient height where a spring's shot may be marked and/or measured directly
6) optional - an apparatus which simultaneously drops one object while projecting a similar object horizontally

One of each of the following is needed for the entire class:

1) a securely mounted horizontal surface at a height of 1.5-2 meters above the floor where the students will hold their 'shooters' for the **You Bet Your Grade** part of the experiment
2) a low waste paper basket

Strategy:

INSTRUCTORS PREPARATION:

1) Mark the 'relaxed' position of the spring on the side of the shooter.
2) Stretch and shoot the spring vertically such that it goes to a height of about 50 cm. Make enough shots so that you are confident of the measurements. Mark this stretch on the side of the shooter and number it #1.
3) Stretch and shoot the spring so that it goes to the greatest height that you are going to use. Again, make enough shots so that you are confident of the measurements. Mark this stretch on the side of the shooter and number it #6.
4) Measure the distance between the two marks (#1 and #6) and divide it by 5. Measure down from #1 a distance equal to the result and mark that point #2. Repeat the measurement for points #3 and #5, intentionally skipping where #4 should be. (A suggestion was made to drill holes at each of these points to allow a small nail to be inserted and the paper clip hooked on the nail. Pulling the nail fires the spring.)

CLASS ACTIVITIES:

1) Have the students fire the spring vertically from each of the indicated stretches. They should record ALL of their data and decide which of the points are consistent and which are in error. (Does the height get more consistent as the student gets more experience?) (Does it make a difference if a different person does the shooting?)

2) Plot a graph of height vs. stretch. (Is this graph a straight line?) (Does it go through zero?)

3) Calculate the initial velocity of the spring (v_o=sqrt(2gh)) for each of the stretches and plot a graph of the initial velocity vs. stretch. (Is this graph a straight line?)

4) Demonstrate that a projectile fired horizontally will take the same amount of time to reach the ground regardless of its initial horizontal velocity. This should demonstrate that the vertical acceleration of an object is independent of the horizontal acceleration with the resulting motion being the sum of the two.

5) Show the students the board you have mounted horizontally and how their shooter should be placed. Also show them the waste paper basket that they will be shooting into.

6) Have the students predict, from their graphs, the initial velocity of their spring for a stretch equal to what would be #4.

7) Have the students calculate the time that it will take for **the sp**ring to fall from the board to the top of the waste paper basket. (t=sqrt((2H)/g)) For a high school class, you might just tell them to calculate the time to fall and let them figure out that the spring doesn't fall to the floor but only to the top of the basket.

8) The students should then calculate where to place the basket. (R=v_ot)

9) Place the center of the basket at the calculated place and have them try shooting. (Did they hit it and how many tries did it take?)

Expected Results:

The results for the first few shots should be somewhat inconsistent but, after 5-10 shots, they should improve greatly. Generally the shots should group within about 10% of the average value for each stretch.

Changing the person doing the shooting usually makes a noticeable difference because each person has their own unique way of releasing the spring. Using a shooter with holes and a nail release along the side should eliminate this difference.

The graph of height vs. stretch should, with the possible exception of the first point, be a straight line. It will probably not go through zero since a spring is linear only from the point where all of the coils are separated and it usually takes some small initial stretch to completely separate all of the coils.

The graph of velocity vs. stretch should **NOT** be a straight line because of the square root used to calculate it but, for the small sample of points tested, it will probably be very close to a straight line.

Evaluation:

A student's grade is based on how many shots it takes for the spring to land in the basket. (First shot = A, Second shot = B, etc.)

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Physics Lab Rockets

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Objectives:

To promote interest in laboratory work at the beginning of the high school year.
To discover some qualitative variables involved in making a balloon rocket on a string.
To promote team activity and cooperation by preparing for and having a balloon rocket contest.
To shoot a model rocket outdoors and calculate its altitude.
Three levels of interest:
1. To calculate rocket's altitude by using angles, triangles, and proportions.
2. To compute its altitude by assuming its path is perpendicular to the eye level plane above grass and use the tangent function.
3. To assume rocket's trajectory is a straight line at a non-right angle to the eye level plane and to have each team measure the angle of elevation at two distances in line from the launch point and move over to another line and do the same (see wire model).

Materials:

FOR EACH GROUP: A picture of a line hanging from ceiling to lab desk with a straw and a balloon on it; roll of Scotch tape; straw; packet of a dozen assorted balloons; a monofilament line hanging from ceiling to be attached by each group to their lab station in the classroom; two sighting instrument kits made up of a ruler with a picture of an upside down protractor on it and a plumb line (string and a weight) taped to the point of vertices on the protractor.

FOR THE CLASS: A not too windy day; a grass field 30 by 100 meters; one or two identical model rockets ready to launch; half-dozen rocket engines that will propel the model to a height of 20 to 30 meters; three ropes with knots at 5 meter intervals 30 to 40 meters long, ready to be stretched out at various convenient angles from the launch point; a coat-hanger wire model of a tetrahedron in which the vertices (corners) are held together by rolled up rubberbands and able therefore to be adjusted to various angles.

Strategy:

INTRODUCTORY ACTIVITY: Blow up balloons and let them fly out of hand; watch their random motions; students will thread the prepared line from the ceiling through a straw and tie it to the lab top; tape blown up balloon(s) to the straw and let them fly;

While the groups are experimenting, the teacher can walk around and give clues to "What's happening?". Discuss: action-reaction, conservation of momentum, pressure in an uninflated and inflated balloon, catastrophic punctured balloon, and the conditions needed to make a balloon rocket. Also the teacher will walk around with the wire tetrahedron and show the possible flight paths of the model rocket to be fired, the geometric line of sight, and the angle of elevation to be measured.

Students are to be preparing their design for the contest "shoot off" at the "teacher's shooting range". Maximum height from floor wins. After experience with a half-dozen shots, students should be ready for the contest.

BALLOON CONTEST DATA (best of two shots)

Trial	1	2	(height from floor)
Team A,B,C,...(circle one)			

ACTIVITY: After the contest the whole class will go out to the grass field to shoot the model rocket. Before the rocket launch, student groups will learn the use of their sighting instruments. Before each firing, teams will pick one station on the stretched out ropes radiating from the point of launch. If a student group wants to launch the model rocket, they must learn the 14 safety points of the model rocket society which come with the engines. Otherwise the teacher should always launch the rocket.

MEASUREMENTS

TEAM A,B,C,... (Circle one)	Distance of station from launch point on line 1,2,3.	Angle of elevation
First launching		
Second "		
Third "		
...		

Conclusions:

Rockets should reach a consistent altitude by using the same model, same engines, and the same launch angle. Students will learn the safety points of launching a model rocket.

On the first level of interest, students, by drawing similar triangles with the measured angle of elevation, should be able to calculate the altitude by making a proportion.

On the second level, students should determine the altitude by making the tangent of the elevation angle equal to unknown altitude divided by the distance from launch point and solve the equation.

On the third level, a group will divide into two and stand in two locations on one of the rays (knotted ropes). They will measure two elevation angles and draw an oblique triangle the base side being the distance between their positions on the ray. Having two angles and the included side of an oblique triangle, the group can determine a second short side by the "Law of sines". Using this side, the closer elevation angle and the sine function, students will be able to figure out the altitude of a rocket with any non-right angle trajectory to the level plane. In all these cases, a good figure is worth more than all these words; but especially the wire tetrahedron model will be useful in showing the various possible trajectories in three dimensions.

A measurement of time (seconds) opens up the whole world of motion.

Evaluation:

Student grades will be based on scale drawings of triangles, angles of elevation and the appropriate calculations. Also, the answers to the questions below will be considered.

Questions:

1. When does a balloon act like a rocket?
2. Name some variables that influence the balloon's flight?
3. 20 is to 40 as 60 is .

4. Similar triangles have the same shape but a different   .
5. Would a real rocket work better in outer space?
6. A real rocket's mass is mostly   .

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Stress and Strain

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Objectives:

Grade level- Junior High

1. To show the stress and strain involved in the movements of the earth's crust with the use of working models.

2. To show how the forces of compression, tension, and shearing effect the movement of the earth's crust.

3. To show how materials effect the movement of the earth's crust.

Materials needed:

The following materials are needed to construct each model:

1. compression model - one piece of wood (30 cm x 15 cm), two pieces of wood (1 in. x 2 in. x 30 cm), two pieces of wood (1 in. x 2 in. x 15 cm), two bolts 30 cm long, and two wing nuts;

2. tension model - one piece of wood (30 cm x 15 cm), two pieces of wood (1 in. x 2 in. x 30 cm), two pieces of wood (1 in. x 2 in. x 15 cm) 2 pieces of screen (15 cm x 10 cm), two screw hooks, and string;

3. shearing model - one piece of wood (30 cm x 15 cm), two pieces of wood (1 in. x 2 in. x 30 cm), two pieces of wood (1 in. x 2 in. x 15 cm), 2 grooved pieces of wood (7 cm x 20 cm x 1 in.), two screw hooks, and string;

4. each model also requires nails, screws, clay, styrofoam, rubber foam, toothpicks, and masses.

Strategy:

INSTRUCTOR'S PREPARATION:

1. The models were made by attaching the two 30 cm pieces and one of the 15 cm pieces to the baseboard.

2. On the compression model drill two holes the size of the bolts in each of the 15 cm pieces. Pass the bolts through the holes and attach with the wing nuts.

3. On the tension model attach the screen to the 15 cm pieces of wood. Attach the screw hooks into the movable 15 cm piece of wood and place the string through the hooks.

4. On the shearing model place the grooved pieces of wood on the baseboard and attach screw hooks to the opposite ends of each grooved piece. (It may be necessary to place a thin strip of wood or plastic along the 30 cm sides to keep

the grooved pieces on the baseboard as they move.) Place the string through the holes of the screw hooks.

5. The styrofoam, rubber foam, and clay are placed in or attached to each model. The toothpicks are placed in each of the materials.

CLASS ACTIVITIES:

1. On the tension and shearing models the students are to place masses on the strings in equal increments and note the movement of materials being tested.

2. On the compression models the students are to turn the wing nuts on each side at an equal rate and note the movement of the materials being tested.

3. The force can be calculated mathematically with advanced classes or spring scales that read in newtons can be used in place of the masses.

Expected results:

1. On all the models the students should note that the clay requires more force to move or break than the styrofoam or the rubber foam.

2. On all the models the toothpicks in the clay not only move apart or together but also move at angles to one another showing the forces at work below the surface. (It was suggested that other models could be made with plastic sides to show the movement of the layers below the surface. Also by using different colors of clay or foam the sub-surface movement might be more visible.)

Conclusions:

The movement of the earth's crust is caused by convection currents below the surface. This movement causes some plates to come together as in the case of India and Asia forming the Himalayas, while other plates move apart as in the case of the Mid-Atlantic Ridge, while still others move along each other as in the case of the San Andreas Fault.

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Simple Machines

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Objectives:

Adaptable to grades 1 to 12

The student will be able to:

1) define and give examples of "work" and "machine"
2) identify simple machines (inclined plane, screw, lever, wheel and axle, wedge, and pulley)
3) classify simple and compound machines
4) name body parts that can be used as simple machines

Materials:

paint can, book, spring scale, meter stick, string, milk carton, several pulleys, toy car--weighted, three boards-same length, three boards-different length, long pole

Strategy:

Work and Simple Machines

Have several students attempt to open an empty paint can with their hands or attempt to move a heavy desk. Have the students determine that although force was used, the objects did not move a distance and there was no motion; thus, no work was done since work is equal to force times distance.

Then have a student open the paint can by using something to pry off the top of the can. Explain that the object was used as a lever, one kind of simple machine, and that a machine is something that makes work easier to do. Also help the students discover that two or more simple machines can be used together to make compound machines.

Activity-Lever

Tie a book to one end of a meter stick. Use a milk carton weighted with dirt or sand as the fulcrum, the point on which the stick rests or turns. Set the fulcrum at the 15 cm mark. On a chart, record where the fulcrum was set, the load arm length, and the force arm length. Use the end of the spring scale to pull down the end of the meter stick and record the force shown on the scale. Repeat the steps above for 20 cm, 25 cm, 30 cm, and 35 cm. Discuss the placement of the fulcrum in relation to the placement of the load and the amount of force needed to lift the load. Have the children discover the direction the load moves and the direction of the force.

Activity-Pulley

Use a horizontal bar to attach a fixed pulley, a combination of a fixed pulley and movable pulley, and a combination of several fixed and movable pulleys. Lift a load attached to a spring scale straight up in the air. Next, lift a load attached to a fixed pulley, then a fixed and movable pulley, and finally, a multiple pulley combination. Record the force needed for each. Discuss which one required the most force to lift the load. Which one required the least force. Determine the direction of the load and the force for each kind of pulley. Determine the relationship of the number of pulleys used and the amount of force needed to lift the load.

Activity-Inclined Plane, Screw, Wedge

Discuss the relationship of the inclined plane, the wedge, and the screw. Next, attach a car to a spring scale and lift up in the air. Then, pull a car attached to the spring scale up three different inclines--the same length, but different heights. Pull a car up three different inclines with different lengths but raised to the same height. Record the force for each. Notice the relationship of the length and height of the inclined plane and the amount of force used.

Activity-Wheel and Axle

One person holds a stick with one hand while a partner places her/his hands on either side of the person holding the stick. The partner tries to turn the stick "wheel" while the person holding the middle tries to keep the stick from turning. Next, the partner moves her/his hands farther apart and tries to turn the wheel. The partner continues to move the hands apart until the wheel turns easily. The person's arm acts as the axle, and the pole is the wheel. The children determine the relationship between the size of the wheel and the amount of force needed to turn the wheel.

Activity-Culminating

Name body parts used as machines. Rapidly classify machines placed in a brown bag. Use as a team game.

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Demonstrating The Kinds of Energy

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Objectives:

1. To investigate the general gas laws and learn how to apply them.
2. To develop a theory of molecular motion that explains the behavior of gases both qualitatively and quantitatively.

Materials needed:

Flask; one-hole stopper with thermometer and ruler attached; clear tape, rubber tubing; beakers; pistons; weights of different masses and graph paper; Safety Glasses.

Introductory Activities:

1. Use small inner tube with weights to introduce the concept of pressure as a force per given area.
2. Have a volunteer sit on an inner tube while someone uses the hand pump to lift them. Permit students to orally discuss what is taking place on the handle of the tire pump, the pump cylinder and the inner tube.

Procedure:

SAFETY GLASSES MUST BE USED FOR THIS ACTIVITY.

Station One:

1. Place the rubber stopper with the attached ruler and thermometer into the flask; (option) add food coloring to the water in beaker.
2. Place the dried flask into the water filled beaker.
3. Notice the temperature inside the flask and position of the liquid in the tubing.
4. Take a reading from the thermometer and the ruler.
5. Convert the degrees Centigrade to degrees Kelvin.
6. Graph your result from your charts. (Temperature vs. Volume)

Station Two:

1. Suspend the piston on a stand. Use different weights to show increased pressure and decreased volume. Permit students to make charts and graphs.

Conclusions & Evaluation:

The conclusion of this lesson is that students will be able to discover two of the general gas laws from their observations, their chart and their straight line and curved graphs. (Boyle's and Charles'). Orally related questions may also be used to further challenge the students' understanding of the behavior of gases.

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Come Fly With Me

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Objective:

For intermediate grades through high school

1. Students will state Bernoulli's principle which is "the pressure in a moving stream of fluid is less than the surrounding fluid."

2. Students will observe examples of Bernoulli's principle.

3. Students will apply what they have learned about guiding airplanes by designing and constructing a model glider whose direction of flight can be controlled.

Materials needed:

For Demonstration: notebook paper, shoebox, text book, medium sized ball, straws, water, beaker, vacuum cleaner with exhaust valve, ping-pong ball

For Activity: shoebox, styrofoam, thread, rubber bands, unsharpened pencils, straws, fan

Strategy:

Through opening demonstrations students should be able to formulate a relationship between moving air streams and the effect they have on objects in the path of the stream. The following demonstrations will be utilized:

1. Place two textbooks with a sheet of notebook paper on top on the table top. Ask a student volunteer to attempt to blow the sheet of paper off the books by blowing under the paper. (The paper should be forced down.)
2. All students hold their textbooks vertically and place a sheet of notebook paper in the book so that the paper hangs over the edge away from them. Students attempt to force the paper down by blowing across the top of the paper. (The paper should be pushed up.)
3. A student volunteer blows through a funnel which has a ping-pong ball in it. He/she attempts to blow the ping-pong ball out of the funnel. Attempt to blow when the funnel is right side up and also when it is inverted. (The ball should stay in the funnel regardless of the direction the funnel is held.)
4. Place medium sized ball on the nozzle of the vacuum cleaner exhaust. Turn the vacuum cleaner on. (The ball should levitate at some height above the vacuum cleaner in the air stream.)
5. Blow through a half straw across the top of another half straw that is placed in a beaker of water. (A spray of water should come out of the straw.)

After these demonstrations the instructor will lead a discussion of the events observed. Stress where the high pressure regions and where the low pressure regions are. Diagram this on the board, label the highs and lows. It should be apparent that the low pressure areas are where there is a moving stream of air. State Bernoulli's principle. Relate the principle to air flight.

Introduce the activity of controlling direction of flight. Define terms ailerons, elevators, rudders. (Ailerons are flaps that can be raised or lowered on the wings, elevators are flaps on the tail, and rudders are on the tail.)

1. Wings and tails are made of styrofoam meat packages. Wings have dimensions of 20 cm x 5 cm. Ailerons should be rectangles on the back edge of the wing and evenly spaced from the center of the wing. Sides of the ailerons should be cut and the front edge should be folded. Tails are 15 cm x 4 cm with elevators made the same way as ailerons but they will tend to be a bit smaller. About 3 cm from each end of the tail fold the tail up and place a 2 cm slit though the folded part to form rudders. These should be folded to the left and right.

2. Attach the wing and tail to the pencil with rubber bands.

3. Adjust the wing and tail so that the plane balances when holding by a thread attached to the front and rear of pencil.

4. Hold plane in front of wind tunnel. The wind tunnel is made of a shoebox that has sections inside made of poster board and the back cut out. Inside the sections are rows of half straws. This provides a steady even stream of air flow when placed in front of a low speed fan.

5. Test each control by bending the ailerons, elevators, and rudders in all combinations.

Conclude activity with a group discussion of concepts. Results of the tests should show that ailerons cause one wing to dip to the right or left, elevators cause the plane to nosedive or rise up, and rudders control left or right turns. Relate these movements to air flow and high and low pressure.

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Forces and Acceleration

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Objectives:

1. To measure the time it takes a person to travel a known distance when a constant force is applied.

2. To construct a distance vs. time graph for the data collected for objective #1.

3. To interpret the distance vs. time graph and make predictions based upon the graph.

4. To learn that when a constant force is applied to a mass a constant acceleration will result.

Materials Needed:

The following materials are needed for each group of 2-4 students:

1 spring balance
1 tow rope
1 coaster cart (an enlarged skateboard)
1 stopwatch
4 data sheets
4 sheets of graph paper

For the entire class the following items are needed:

1 measuring tape 15 m long
masking tape
overhead graph
If time permits, 2 rideable air hockey pucks. (see Physics Teacher, Nov. 1989)

Strategy:

INSTRUCTOR'S PREPARATION:

1. The data table used by the students should contain the following information:
   A. the distance traveled
   B. the amount of force being applied
   C. the time it takes to travel each distance
   D. if each distance is traveled more than once, an average column

2. The graph that each student is to make is a distance vs. time graph. Distance should be plotted on the vertical axis and time plotted on the horizontal axis.

3. The coaster carts can be constructed out of 3/4 inch plywood or a similar material and roller skate wheels. Alternatives to constructing these carts are roller skates, skateboards, or even wheeled office chairs.

CLASS ACTIVITIES:

1. Have the students pull each other down the hall, on the coaster carts. Distances of 5, 10 and 15m will have been measured out on the floor. While doing this another member of the group will record the time that it takes to travel each designated distance. The student pulling the cart **must** maintain the same force reading on the balance throughout the entire distance.

2. Other group members record on the data table, the distance traveled and the amount of time it took to travel that distance. At least 3 different students should ride the cart.

3. Each student is to plot his/her own distance vs. time graph. (Is the graph a straight line? If not, what is it? Is your graph like your partner's? How are they the same? Different?

4. Based upon their comparisons the students are then to predict what the graph would look like for a person who is twice as massive as themselves. Half as massive.

Expected Results:

The first thing the students should notice is that their velocity continued to increase. This will be obvious to them from their experience of riding on the cart. The student will also have a graphical representation of what they had experienced while riding on the cart.

Since each student will have ridden the coaster carts more than once with a different amount of force being applied each time, they will also come to the understanding that the more force applied the greater the amount of acceleration.

When the students compare their graph with that of their partner's they will see that everyone experienced a constantly changing velocity (acceleration). Therefore, a constant force produces a constant acceleration.

Finally, the students will see that the acceleration experienced by each one of them was not the same. The difference in acceleration that each one of them experienced is related to the amount of force being applied and the amount of mass to which the force was being applied ($a = F/m$ or $F = ma$).

Evaluation:

The student's grade is based upon their data table, graph and their interpretation of the results.

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Determining A Spring Constant

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Objectives:

(For grade 8 or above)
To determine the spring constant of a hanging spring.
To interpolate and extrapolate information from a graph.

Materials Needed:

The following materials are needed for each group of 2-4 students:
1) a spring support made from a 6" piece of 1" by 4" and a 18"by 3/8" dowel rod
2) a spring support is made by drilling a 3/8" hole in the 4" by 6" piece of wood 4" from the length and 2" from the width. Insert the dowel rod and secure with a little white glue or any wood glue
3) a clamp from which to hang the spring
4) spring (10 to 15 cm in length)
5) meter stick or metric tape
6) set of masses (10-250g)
7) several objects of unknown mass (a bolt or nut between 50 and 150 g)
8) graph paper
9) Grease pencil (optional)

Strategy:

Part I

1) Prepare table as shown:
   f = force in newtons.

f	**stretch in cm**

2) Hang the spring from the support.
3) Select a mass from a set of mass weights (be sure that the mass will stretch the spring at least cm).
4) Convert the mass to force in newtons. Should you use a 250g mass (.25kg), multiply its mass by 9.8 m/sec^2 to get 2.4kgm/sec^2 (2.4 newtons).
5) Support the mass with your hand so that the spring is not stretched and record this position. Slowly release the mass and, when the spring reaches its lowest position, record this position.
6) In your data table record under f, the force in newtons and in stretch in cm record the number of centimeters of stretch.
7) Continue numbers 2 through 6 using four or five other masses.
8) Construct a graph from the data in your data table.
9) Compare your graph with other groups. Are they similar or are they different?

Part II

1) Place an object of unknown mass on your spring and record the stretch.
2) Using the graph determine:
   a) The force in newtons of the object.
   b) The mass of the object.

Conclusions:

1) What can you determine from your graph and others?
2) What would the graph look like if you used springs of different materials, lengths or/and strengths?

Evaluation:

A student's evaluation is based on the accuracy of their unknown masses.

References:

Science Laboratory Techniques Rolland B. Bartholomew and Frank E. Crawley
Addison-Wesley Publishing Company.

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HELICOPTER

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Objectives

1. Students will be able to demonstrate the effects of aerodynamics on a wide board.
2. Students will be able to name parts of the helicopter.
3. Students will know the the meaning of the terms: lift, thrust, drag. and weight.
4. Students will learn how to construct a paper device, that can fly and be controlled by manipulating its parts.
5. Students will gain an appreciation of the aerodynamics involved in flying a helicopter.

Apparatus and Materials

1. Model helicopter
2. Card board (1"X 3')
3. Paper (11"X 14")
4. Paper strip (1"X 7")
5. Scissors
6. Cellophane tape
7. Ruler

Recommended Strategy

Perform the following activities:

Background

A. Discuss the development of the helicopter through the ages:
   1. State Leonardo da Vinci's artistic contribution. (1500)
   2. Discuss the first manned helicopter, developed by Paul Cornu and later Louis Bre'guet (1907)
   3. Discuss the first practical helicopter designed by Henry Focke and later Igor Sikorsky (1939)

Activities

A. Rotor design

The helicopter's main rotor and tail rotor do the same jobs as the wings, propeller, and rudder of an airplane. To understand how a rotor works, experiment with a model rotor blade made of a piece of stiff cardboard about 3 inches wide and 3 feet long. Hold one end of the blade with both hands, and turn around in a circle. As you are turning, adjust the angle at which the blade meets the air. This angle is called the pitch of the blade. Vary the angle of the blade as you turn and you will notice that it tilts. The greater the pitch you give the blade, the higher the blade tilts because of its increased lifting power.

B. Paper Airplane

(See paper airplane instructions: any science book)

C. Helirotor

Cut a 3 inch slit in a (1 inch X 7 inch) piece of paper; now make a 1/3 inch slit on each side of the paper just below the three inch slit. You now have two prongs on the top half of your strip of paper. Curl each prong in a direction opposite to each other with your finger nail. Fold the bottom half of each side of the sheet inward until they overlap. Try launching your helicopter from as high as possible. Reverse the prongs. Discuss the aerodynamics involved.

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PROJECTILE MOTION

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OBJECTIVES

To measure muzzle velocity of a projectile device.
To predict maximum range of a projectile device at various angles.
To measure range of device at various angles.

APPARATUS NEEDED

Calculator, Tape measure, stopwatch, projectile device, projectiles. (This demonstration used a "Lobster," a device used in training tennis players.)

RECOMMENDED STRATEGY

1. Throw a ball or frisbee out to groups of students. Ask students to toss the ball back and forth. Have students jot down their observations and and a description of the motion of the ball.

2. Introductory discussion: What name could we give to this category of objects? (PROJECTILES) Can you think of some other projectiles? What are some of the characteristics of projectiles in motion? (List all suggestions on board or overhead. If necessary elicit the following terms: velocity, acceleration, time, horizontal motion, and vertical motion.

3. Explanation: In order to analyze projectile motion with all the listed characteristics, we would need a NASA computer. We are going to ignore all factors except velocity, acceleration and time. If necessary review horizontal velocity and vertical velocity.

4. Presentation of activity:
   a. Work in lab groups.

   b. Explain use of the projectile device. The muzzle velocity can be determined by aiming the muzzle straight up. Record the time required for the projectile to leave the muzzle and return to the ground. Do 5-10 trials, find the average round trip time.

   c. Choose 2-3 angles. Predict the range using vector analysis and trig calculations. (See Math Notes) Use the projectile device, measure the range of the projectiles. Compare projected range with actual range. What are the sources of error? (Consider using complementary angles)

5. Post activity discussion: Explain why there were differences between predicted and experimental value of range. What were the variables? How could variables be controlled? What conditions would optimize experimental values? How could

experiment be improved? What other ways could projectile motion be tested?

NOTES

1. Non-Math oriented classes: This activity can be modified for use with students who are not in high school physics. Students could be asked to predict which angle will make the ball go further. They can begin with actually testing the device and could graph the angle vs. distance shot.

2. Math Notes

Muzzle Velocity **V(muz) = A * T**
Where **A** is the acceleration of gravity and
T is half the round trip time for a ball shot directly upward.

Range Calculations The muzzle velocity does not change as the angle is changed. It can be resolved into a vertical and horizontal component.
Consider the angle with the horizontal to be Theta then
V(ver) = V (muz) * sin Theta and
V(hor) = V (muz) * cos Theta
The time of flight can be calculated using the formula, **V(ver) = A * T_{up}** and solving for **T_{up}**.
Time of flight is 2 * T_{up}.
Since the V(hor) is not accelerated,
Range = V(hor) * time of flight

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Newton's Laws of Motion

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Objectives

To be able to state Newton's 1st,2nd, & 3rd laws of motion.
To initiate an understanding in describing the principles and dynamics involved in the Laws.
To apply the laws to describe everyday occurances.

Apparatus Needed

1 place setting for a table & table cloth toy dump trucks, marbles or standard weights, 1 cup, string, sand, and slingshots (apparatus), stop watch, meter stick & tape 1 embroidery hoop, 1 cup or flask, and a coin 3 or 4 blocks of wood, 1 glass 2 washers & parachute 1 mini trampoline Video recorder & television Video tape footage of baseball player sliding into base and of a rocket launching. Water rocket

Recommended Strategies

Review how motion is relative and how it can be described and measured.

Discuss forces and how they're described and measured.

Place table setting on table cloth, ask students to guess what will happen. Pull table cloth from under place setting, set embroidery hoop on cup - then place the coin on top of the embroidery hoop. Pull the hoop from under the coin. Stack the blocks of wood on top of each other, then set the glass on top of the blocks. Knock the bottom block from under the other blocks,demonstrating that an object will remain at rest until acted upon by an unbalanced force.

Show video tape footage of a baseball player sliding into base. Play game Red Light Green Light. Pick three players, teacher stands in front and says green light (the students run as fast as they can to try to touch the teacher first); however, the teacher will say red light (the students must stop like a statue immediately) while turning around. If caught moving the student will have to return to the starting point. The object of the game is to catch the child moving, therefore demonstrating that an object or mass in motion will stay in motion at a constant velocity until an external force acts on it.

Measure one meter on a flat surface, then mark the beginning and the end of the meter with tape on the flat surface. Remove the meter stick. One piece of tape will be your starting point; the other piece of tape will be your stopping point.

Place one rubber band around the `slingshot'.

Put the`slingshot' behind the beginning or starting point. Place the truck behind the starting point, but in front of the slingshot. Stretch the rubber band back 2 in. Release the rubber band so that it hits the truck. Clock the time it takes the truck to travel 1 meter.

Now, place two rubber bands around the `slingshot':

Repeat the previous directions.

Now, place three rubber bands around the `slingshot':

Repeat the previous directions.

Chart the data, demonstrating the relationship between mass, acceleration, and force.

Take two washers of the same size. Attach a parachute to one of the washers. Standing on desk, drop both washers at the same time. Demonstrating the relationship the direction of a force has on the acceleration of an object.

Have students jump up and try to stay up. Then, jump up and down on the ground. Next, have the students jump up and down on a trampoline.

View a video tape of the space shuttle launching. Blast off a toy water rocket. Demonstrating that forces come in pairs, and for every action there is an opposite and equal reaction.

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Simple Machines

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Objectives

1) Student will see a large number of everyday items in terms of simple machines i.e. levers,inclined planes, wheels and axles.
2) Student will experience the use of and see demonstrations of simple machines.
3) Student should discover that simple machines reduce the effort required in a task,not the total work.
4) Student will see physics as a part of everyday life.

Equipment and Materials

Variety of simple machines in the classroom or laboratory. (Door handles and hinges etc...)

Simple machines brought from home or work by each student.

Recommended Strategies

Several days before the simple machines activity, assign **each** student in class to bring a simple machine on the assigned day. On each successive day remind the students of their assignment and tantalize them with some "prize" for the best and/or most unique simple machine. Create an atmosphere of suspense concerning the "prize" as well as curiosity and interest concerning simple machines. Get them ready.

On the day of the simple machine activity start by demonstrating some simple tools such as a hammer and nails, pliers etc... (Hammer a nail into a piece of wood with a ball-peen hammer, then try to remove the nail, make a point of the difficulty encountered, and seek suggestions from the class.) After a few sample machines (from tool box and/or kitchen) ask each student individually to show the machine brought to class. The student should categorize the machine (lever, inclined plane) and tell, and demonstrate if possible, its uses. The more unusual items will usually stimulate comments and discussion which must be controlled as time permits.

Often students will forget or not bother to bring any machine. That is their problem. This may be turned into a very positive and creative learning situation. Allow such students to find a machine in the room or among their personal belongings. This is often the best part of the entire activity and under "pressure" machines such as keys, pencils, mechanical pencils, lipstick tubes, compacts, window shade rollers, and an endless supply of machines is created.

As the students present the machines, it might be a good idea to comment on such things as effort vs. work, what the machine is used for, and possible alternatives that might work better.

As the activity is concluded the "winner" is chosen by vote of the class or chosen by the instructor. The "prize" might be a simple machine such as a pop top (lever) with a can of coke attached to it.

Such an activity must be adjusted to grade level, class size (large classes may bring one machine per C.L. group) and time constraints. The activity may by followed with other activities such as lab exercises to quantify the relationship between effort and work, and incorporate concepts such as efficiency and mechanical advantage.

Always emphasize objective #4 to foster an appreciation for, and allay fears of SCIENCE and science classes.

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Retrograde Motion

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Objectives

1) Students will learn the terms for objects in the heavens.
2) Demonstrate the basic motions of heavenly bodies.
3) Using models, show a variety of conceptual schemes explaining these motions.

Equipment and Materials

Model of Herodotus' Earth
Several spheres
Flashlight
Sighting tubes
Three 50 ft. lengths of rope
Epicycle machine

Recommended Strategies

Identify objects in the skies such as the sun, moon, stars, planets, birds, planes, meteors, clouds, comets and so on. A model of each should be available.

Ask students to order these in terms of distance from the earth: birds then clouds are pretty obvious. A discussion of the remaining objects requires some thought; eclipses suggest the correct sun-moon relationship (the sun is further). That the students have not observed the planets and thus have no observed basis for ordering these is a good point of departure for a short survey of historical views.

Orientation on earth: the earth appears to be flat. The sun rises in the east and sets in the west providing a basic set of reference points. From these, north and south are derived.

The sun is the first (as most prominent) celestial object considered. Its apparent motion can be demonstrated by following an imaginary sun at the end of one's finger from the east in an arc across the sky. Other aspects of the sun's activity are its southerly motion in the winter and returning more nearly overhead in the summer, and the length of day at these extremes.

The moon is the next object to be considered; like the sun, it rises in the east, sets west, and can be observed to pass regularly through phases. These phases can be demonstrated using an eclipse model (using discs passing one before the other), and the correct model showing an angular relationship with three spheres and a flashlight.

The stars, considered as a group, are also seen to rise east, set west, given the observer is facing south from a position in the northern hemisphere. Constellations (Ursa Major, Ursa Minor,etc.) rather than individual stars are tracked owing to the number of stars..

Once these observations have been established, various "explanatory" schemes are introduced. Plato's geocentrism can be contrasted with Aristarcus' heliocentric view. At this point one further observation is introduced: planets (or "wanderers") can be seen to move in a band of eight degrees on either side of the ecliptic; moreover, these planets seem to reverse directions from their observed motions to a retrograde motion for a period of time (during which they also appear brighter), before resuming their original path. The Platonic view has difficulty with these new data. Accordingly, Ptolemy modified Plato's view, retaining the geocentricity and circular motion while moving the geometric center of these circles from the Earth to points in space. This innovation can be demonstrated with an epicycle machine. Ptolemy's was the dominant view of planetary motion for nearly 1500 years, until Copernicus' observations led once again to a heliocentric (or sun centered) formulation. That this view can account for "retrograde motion" can be demonstrated by making a series of observations from one moving planet to another when both are in opposition to the sun. Thus both the apparent change in direction and the increased brightness "fit" a sun centered model.

Heliocentrism, then, was revived and built upon with increasing precision with new observations made by Galileo (using a telescope) and culminating with Newton's Laws of Motion.

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INERTIA

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Objectives

1) Students will learn basic understanding of inertia.
2) Students will demonstrate some activities illustrating inertia.
3) Students will develop a basic understanding of Newton's laws of motion.

Apparatus Needed

Balls various sizes, pie pans with one fourth slice removed, pennies, heavy paper circle, checkers, skate board, stuffed animal, glass, two eggs (one boiled, one raw), cloth napkin, glass of water and straws.

Recommended Strategy

Students should have prior knowledge of speed, force, acceleration, gravity and friction. Demonstrate inertia by snatching a cloth napkin from under a glass of water, and a paper circle from under a checker so that the checker falls into the glass and spinning the two eggs. Group students into cooperative groupings to carry out the following activities:

Activity 1 - Place a ball in the pie pan and spin the ball. Repeat this activity using two balls of different mass.

Activity 2 - Put a ball in motion and try to blow it off of its path with a straw. Repeat this activity using balls of various masses.

Activity 3 - Stack five checkers one on top of the other. Using your fore-finger flick another checker sharply against the bottom checker of the stack to move it from pile keeping pile undisturbed.

Summary

Discuss Newton's first law of motion with students. Have students answer these three questions: 1) How does the pie pan and ball activity help prove the first law of motion? 2) Which ball was the hardest to move off of the straight path? 3) Does inertia increase with mass?

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Coefficient of Restitution

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Objectives

1. To investigate the variables (factors) influencing the bouncing of balls.
2. To find the coefficient of restitution for four balls.
3. To observe how the manipulated and control variable are correlated by graphing the data.

Apparatus Needed

An overhead projector, overhead projector pens, graph transparency, graph paper, metric ruler, 4 meter sticks, 4 basketballs, 4 golf balls, 4 tennis balls ,4 superballs, 20 #2 pencils, masking tape, 1 beach ball, 1 Nerf ball, 1 clay ball, 1 Earth ball.

Recommended Strategies

1. Make a collection of balls of different sizes, weights,and materials.
2. Use such a collection for demonstrations. Get the students to question the collection. Is the biggest ball the heaviest? Is the smallest the lightest? Which ball will bounce the highest? Why does the superball bounce so high?
3. Have the students work in cooperative learning teams. One student will be a demonstrator. One student will be an observer. One student will be a recorder.
4. Using masking tape mark heights of 40 cm, 80 cm, 120 cm, on the wall where the floor surface is hard. Call these heights H1. Instruct students to drop each kind of ball from the three heights and measure the height of the rebound. Record this data on the Data sheet. Call the rebound height H2.
5. Instruct the students to calculate the coefficient of restitution,(Rebound Height) / (Initial Height).
6. Graph H1 on the horizontal axis and H2 on the vertical axis.
7. Graph the results from the data sheet using a different colored pencil to represent each ball.

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Inertia

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Objective(s):

Students will be able to explain inertia.
Students will be able to identify the factors that determine inertia.
Students will be able to compare the acceleration of an object with a net force to an object without a net force.
Students will be able to state Newton's first law of motion.

Apparatus Needed:

Card table, tablecloth, two china plates, heavy plastic plate, light plastic plate, styrofoam or paper plate, plastic drinking glass, index card, two pennies, five nickels, paper disc, small plastic disc, three-wheeled cart or rollerskate, dot/tape time, two identical shaped objects of different weights, 500 gram weight, distance/time posterboard graph, average/speed posterboard graph, paste or tape.

Recommended Strategy:

Students should have prior knowledge of speed and acceleration measurements and graphing.
Demonstrate inertia by snatching a tablecloth from under two china plates.
Student teams are to complete and write up the following activities. Each write up should include a prediction and an explanation of what happened and why.

Activity 1 - Place a heavy plastic plate in the center of the table on a tablecloth. Then snatch the tablecloth from under the plate. Repeat this activity using a light plastic plate and then a styrofoam plate.

Activity 2 - Place an index card flat on top of a plastic drinking glass. Place a penny on the center of the card. Hold the base of the glass with one hand. Then using the forefinger of the other hand, flick the card forward so it moves out from under the penny. Repeat this activity using a plastic disc and then a paper disc.

Activity 3 - Stack 4 nickels one on top of the other. Using your forefinger, flick another nickel sharply against the bottom coin of the stack. Repeat this activity using the penny and then the plastic disc.

After the activities, conduct a classroom discussion of factors of inertia observed in each activity. Next have each student handle two objects, identical in shape and appearance but different in weight, to distinguish which has the greatest inertia.

Set up demonstration using a three-wheel cart or rollerskate with an accelerometer on top. Attach the end of two tapes from the dot/tape timer to the cart. Start the timer and give the cart an initial push. Impress on students to observe the accelerometer. Have two students, one for each tape, mark and cut the tape into a series of four dot strips. Take the first strip of one of the students and paste or tape it in the lower left corner vertically on the distance/time posterboard graph. Then take the second strip and paste it with its lower left corner next to the upper right corner of the first strip. Continue pasting each successive strip until you get to the top of the graph. Draw a line connecting the top of the strips. With the second set of tape strips, lay them one at a time next to each other on the horizontal axis of the average speed/time posterboard graph. Start with the first strip to the end of the graph. Draw a line across the top of the strips. Next tie a cord to the cart and place the other end through a pulley at table level and then up to a pulley on a ringstand. Attach the 500 gram weight to the end of the cord. Once again attach two tapes from the dot/tape timer to the cart. Repeat the demonstration releasing the weight. Then tape the strips in the same way to each of the posterboard graphs.
The class should then compare and explain both graphs. Then discuss inertia, its factors and Newton's first law.

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Pendulum Problems

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Objectives

1. To review the terms pendulum, period, cycle, frequency, independent variable, dependent variable, damping, and displacement.

2. To review the graphs of the functions: $f(x)=x^0$, $f(x)=x^1$, $f(x)=x^2$

3. To determine experimentally the relationship between the length (L) and the period (T) of a simple pendulum.

4. To derive the mathematical equation which represents the relationship.

5. To observe the graphical relationship between the period (T) and the displacement (d) of a simple pendulum.

Apparatus

weights (uniform mass)- one per student
strings (increments of 10cm)- one per student
overhead projector
graph paper
Apple computer/gameport/100k linear potentiometer (see Radio Shack)
\`Pendulum Plotter' disc
meter stick
stand/clamp

Recommended Strategy

1. Construct a simple pendulum in front of class. Begin a dialogue concerning the motion of the pendulum. Use the words, period, frequency, cycle, independent and dependent variable, and control and try to elicit questions. After discussing the effects of modifying a pendulum, conclude that it is the length (under small displacement) that determines the period.

2. Provide each student with a pendulum. Have them determine the period of their pendulum. Discuss the significance of the number of cycles used to determine the period. Record data on the board. Also graph the period (dependent variable-T) versus the length (independent variable-L) using the vertical axis for (T) and the horizontal axis for

(L). But instead of plotting points, tape each student's pendulum to the board. A curve is generated by the pendulum bobs but in this manner we see, maybe more convincingly, that it is the length of the pendulum that determines the period of the pendulum.

3. Distribute graph paper and, using the overhead projector, help the class to graph $f(x)=x^0$, $f(x)=x^1$, and $f(x)=x^2$. Compare these graphs with the graph generated in strategy 2 above. Lead class to discover that the new function 'fits' between $f(x)=x^0$ and $f(x)=x^1$. At this point, speculate that the new function could have a factor of $x^{1/2}$. Now try to get the kids to look back at the table to guess what must be done to the 'L' values to get the 'T' values. With 'good' data you'll arrive at $T= L^{1/2}/5$.

4. Fit the potentiometer to one end of a meter stick and affix this apparatus to a ringstand. Using the gameport, wire the apparatus to the computer. Boot the Pendulum Plotter program. Displace the meter stick and observe the monitor for a graph which shows simple harmonic motion. Allow time for experiments regarding the displacement of the meterstick. What is being graphed now? Ask students to form conjectures from their experiments.

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Sitting on Nails-Boyle's Law

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Objectives:

1. To understand the difference between force and pressure.
2. To illustrate that pressure is a force per unit area.
3. To show pressure is a scalar while weight (i.e. force) is a vector quantity.
4. To show the relation between pressures above and below atmospheric pressure upon the volume of an enclosed gas when the temperature remains constant. (Boyle's Law)
5. To illustrate the graph of an inverse relation.
6. To show the effect of atmospheric pressure on a partial vacuum.

Apparatus Needed:

(Obj. 1-3)
Three 1/2" plywood boards whose dimensions are 40 cm. x 20 cm. The first board has one nail in the center. The second has four nails in the center at the corners of a square about 6 cm. on a side. The third has 420 nails that are spaced 1 cm. apart, covering an area of 30 cm. x 15 cm.
(Obj. 4 & 5)
A modified hypodermic syringe used Boyle's Law Experiment similar to Science Kit and Boreal Lab. Cat. No. 64710. Take off the base and top of the syringe and suspend the syringe from a test tube clamp with the plunger up for positive pressure and with the plunger down for negative pressure. A series of standard laboratory weights are needed to provide the forces.
(Obj. 6)
The final part requires an empty ditto fluid can.

Recommended Strategy:

(Obj. 1-3)
Ask students if they would sit on boards with one and four nails. Show the students the board with the 420 nails and ask them if they would sit on these nails. If you are not successful, you sit on the nails. At this point(s) you should also get one of the students to sit on the nails.
(Obj. 4-6)
Have the students collect data on the volume of air as a function of the pressure on the enclosed air. Have them graph their results. To

illustrate the final objective take an empty ditto can with about a cubic centimeter of water in it; with the cover off the can heat it vigorously. Cover the can tightly and allow it to cool. After it is cooled, you take off the cap and blow up the can with your lung power.

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Newton's Third Law of Motion

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Objectives:

1. To introduce the student to basic concepts of Newton's Third Law of Motion.
2. To introduce the concept of thrust as one of the forces acting on aircraft to make flight possible.

Apparatus Needed:

Rope, 2 spring balances, bucket with holes on opposite sides of bottom, string, balloons, paper clips, straws, pencils, tape, scissors, paper, wire, Xeroxed copy of Space Shuttle, rocket, calculator, carbon dioxide pellet, firing pin.

Recommended Strategy:

Hook two spring balances together held by supports. Adjust the support so that the balance at the right reads 5 lbs. The balance at the left will also read 5 lbs. Increase the pull to the right to 10 lbs. The pull to the left will also be 10 lbs. The pulls of the balances will be found to be equal in magnitude and opposite in direction for all settings of the support.

Fit a small toy airplane with a screw eye above its center of gravity and fasten a pellet of compressed carbon dioxide underneath. Suspend the plane from a wire passing through the screw eye and stretched across the room. Puncture the pellet with a spring driven needle. (Note: Firing pins for cartridges are available at hobby shops.) The plane is propelled forward while the gas is discharged backward.

Attach the nozzle of a balloon to a straw with a 5 to 10 gram mass. When blown up, the balloon will lift off a table with good stability. The balloon without mass is erratic in its behavior. This experiment shows that some control is needed to cause a rocket to behave as you want it to do.

Powder-Propellant rocket. An inexpensive solid-fuel rocket motor (such as Jetexengine) can be purchased at a hobby shop. A chemical pellet is used as the propellant. (Caution: The fuel is inflammable and should be operated outdoors.) Attach this rocket motor to a model airplane or rocket that is suspended from a long horizontal wire. Fasten the engine just below the center of gravity of the airplane or model. Then ignite the rocket by lighting a fuse.

You may want to introduce the principle of action and reaction by having a student demonstrate a model racing car driven by a carbon dioxide cartridge. A good model will attain speeds close to 60 miles an hour.

Some Practical Applications of Newton's Third Law

1. An athlete executes a high jump by pushing against the earth which, in turn, pushes him/her up in the air.
2. We swim by pushing against the water, which reacts, propelling us ahead.
3. A helicopter rises vertically because of the reaction to the downward push against the air produced by its propellers.
4. The jet propelled plane and the rocket are thrust ahead by the force of reaction on their own products of combustion enabling them to fly at altitudes at which there is not enough air pressure for a conventional propeller-driven vehicle to operate.
5. Water of high pressure hoses leaves the nozzle with great speed resulting in a thrust which pushes the hose with such force that one person cannot control it. Most people have experienced this to a much lesser degree with the garden hose.

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Balance and Gravity

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Objectives:

Students will learn the basic concepts of balance and how to determine the location of the center of gravity using a model of the leaning tower of pisa and various other items.

Apparatus Needed:

plexiglass (5cm x 20cm)
string (35cm)
overhead pens
lead weight (100g)
triple-beam balance
beaker (250ml)
salt (2g)
pencil

Recommended Strategy

Have students examine the triple-beam balance and weigh several items. Ask them to notice what are the results of their measurements when the balance is in equilibrium. Raise the question; Where is the center of gravity found using this apparatus?

Make a model of the leaning tower of Pisa from the plexiglass. The model should be slightly larger at the base. Explain that the center of gravity is an imaginary point at which we can consider the entire weight of an object to be concentrated. Place one hole in each of the top corners of the model. Suspend the model from one hole at a time while allowing the string and weight to come to rest below the base. Draw a line from the point of suspension to the base. Repeat this procedure for the opposite side. The X where the lines intersect marks the center of gravity. Place another hole at the point determined as the center of gravity. If you now suspend your weight-on-a-string so that it hangs freely from the center-of-gravity point and lean the tower against a wall while its base stands on the edge of a book, you can find out just how far over it can go without falling. As long as the line remains within the base line of the tower, it will not fall. The instant the line passes outside the base, it falls. Explain to the students that the reason the leaning tower of Pisa has not yet fallen is because its center of gravity still lies within the base.

The lower the center of gravity, the farther over an object can lean. Thus, by concentrating the weight of buildings, cars and boats as low as possible, designers make them more stable.

Ask the students to bring to class at least one item which demonstrates balance or the center of gravity for class discussion.

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Friction

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Objectives:

1. Students will observe that friction is a force opposing movement.
2. Students will observe that different surfaces have different coefficients of friction.
3. Students will observe that friction is more dependent on mass rather than surface area.
4. Students will observe that there is a difference between static (starting) and sliding friction.
5. Students will perform experiments and record measurements and make data tables.
6. Students will observe that there are differences in the measurements and will postulate as to why.

Apparatus Needed:

heavy books, aluminum foil, wax paper, plastic bags, sandpaper, ditto paper, string, tape, spring balances.

Recommended Strategy:

Present the problem to the students - which wrapped book will be the hardest to pull, which will be the easiest to pull. Have the students, as a group, order the wraps from hardest to easiest (a typical answer - sandpaper, aluminum foil, ditto paper, plastic, wax paper.) Let the students touch the wrappings to get the "feel" of them. Students will then experiment with the equipment to find the right order of wrappings, the difference between static (starting) friction and sliding friction, and whether there is a difference when the book is turned on edge versus flat on the table.

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What Is Work?

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Objective:

To show work (w) equals force (f) times distance (d) and the connection between work and potential energy, kinetic energy, and heat.

Equipment:

Single and double pulleys to produce mechanical advantages of 2 to 5, stands and supports for such, string masses from 0.1 to 2 kg, N force scales to 5N, wooden inclined plane about 2 m long, a wood disk or block that can support masses up to 10 kg, a liquid crystal strip about 20 cm long 5 cm wide (the strip should have a temperature change at 25^{o}C to 30^{o}C), two beakers, ice, boiling water, a thermoelectric converter (PASCO SCIENTIFIC, 1876 SABRE STREET, HAYWARD CALIFORNIA, 94545. 1-800-772-8700)

Procedure:

Set up a number of pulley assemblies depending on the number of class experimental groups each with a different mechanical advantage and mass. Determine the force needed to lift at **constant speed** the provided weight, the distance the weight is lifted, and the distance the force at the other end of the string moves as the weight is lifted. A data table can be constructed thus:

mass of object lifted kg	weight of object lifted N	distance object is is lifted m	force used to lift object N	distance the force travels m	column 2*3	column 4*5

Column 6 should be equal to column 7. But column 6 is mgh and column 7 is f*d. Point out that lifting the weight is tiring, because you have done work. How does that work appear on the data table? What is constantly the same in each row? (f*d = mgh) We therefore define work done as f*d. (If f is in Newtons and d is in meters, work has units of Joules.) Mgh is also the work done, but that raised weight has the work somehow in it. Demonstrate this by dropping a weight on piece of chalk. Point out that the weight did work on the chalk, and therefore has the ability to do work when raised. We call that ability because of its position potential energy. Point out that the weight, just before it strikes the chalk has no potential energy. Since we have shown that the work we did was converted to potential energy, then it follows the potential energy was converted to something. Since the weight was moving, the new energy is energy of motion, called kinetic energy.

We know that $V^2{}_f - V_o{}^2 = 2*A*S = 2*g*h$. If $V_o = 0$, then $V^2{}_f = 2*g*h$. Multiply both sides by m. $mV^2 = 2*m*g*h$ or $mV^2/2 = m*g*h$. This states that $mV^2/2$ at end is the same as the $m*g*h$ at the start. This mathematical quantity, $m*V^2/2$ is called kinetic energy, KE.

Next set up an inclined plane so that weights piled on the wooden disc or block will not accelerate as they slide. Tape a liquid crystal strip to the plane's lower third. Demonstrate that the strip changes color with temperature by touching it. Slide the weights and support down the plane. The strip changes color showing heat was produced.

Point out that the KE of the weights as it slid down the plane did not change (no change in speed) but the potential energy did. Why? If we believe that the energy at first equals the energy finally then we must add heat to make a balanced statement;

$$m*g*h \text{ (at first)} = m\,V^2/2 \text{ (at end)} + \text{heat}.$$

Heat must be a form of energy.

To show that heat can be used to make KE and work use the thermoelectric converter, one plate in hot water the other in ice water, in different beakers.

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Oscillations

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Objectives:

(1) To construct various types of pendulums.
(2) To prove that the mass of the bob and the range of the oscillation (5^o-15^o) do not affect the period of a simple pendulum.
(3) To prove that the length of the swing arm does affect the period of a simple pendulum.
(4) To diagram each activity dealing with oscillations.
(5) To graph length versus frequency.
(6) To observe energy transfers in coupled pendulums of the same length.
(7) To demonstrate knowledge of the formula: T=2pi times the square root of L/G.
(8) To use a simple pendulum to measure the gravitational constant G.
(9) To observe the Pulfrich Pendulum and to make predictions regarding the illusions it causes the eyes to see.
(10) To use a pendulum bob to make Lissajous figures.

Apparatus needed:

protractors, graph paper, meter sticks, metric rulers, stop watches, various sizes of dowel rods, string, washers, metal balls, scissors, empty 2 liter plastic bottle, overhead projector, sand, balance, ring stands, metal supporting rods, c-clamps, scientific calculators, tape, polarizing film, eye hooks, wood glue, drill, saw, sand paper, screws, nails, wooden blocks, safety glasses.

Recommended Strategy:

Procedure for Pulfrich Pendulum:
Set a simple pendulum swinging in a plane. Have students observe its back and forth movement. Have students cover one eye with polarizing film and observe the movement of the pendulum with both eyes open. The pendulum appears to swing in a circle either clockwise or counter clockwise, depending upon which eye is covered. Make predictions regarding the illusions.

Procedures for testing variables:
length, mass, and amplitude: Students will work in groups. Set up work stations around the room. Give each group washers of equal sizes, stop watches, protractors, c-clamps, rods, tape, string, and graph paper.

Testing variable length:
(1) attach one washer to each swing arm, (2) release each bob at 10 degrees amplitude, (3) vary lengths of swing arms: 25cm, 50cm, 75cm, 100cm, 125cm, 150cm, (4) one student will count the number of cycles in one minute. (One student will either time one minute, or will time ten cycles) Do three trials. Average data. Calculate the period for each pendulum. Record all data in data table. Graph length versus time. Using formula, find G for each pendulum tested.

Testing variable mass:
(1) keep all swing arms the same length, (2) keep all amplitudes 10 degrees, (3) vary number of washers added to swing arms, (4) record results, (5) reach conclusion about the affect of mass on the period of the simple pendulum. Testing variable amplitude: (1) keep all swing arms the same length, (2) add one washer to each swing arm, (3) Vary the amplitude from 5 degrees to 15 degrees, (4) record results, (5) Reach conclusion about the affect of amplitude on the period of a simple pendulum.

Procedure for coupled pendulums:
Suspend two pendulums of same length from the same thin dowel rod (string could be used in place of the dowel rod); suspend this rod from a supporting rod. Start with the pendulums at rest. Start one pendulum swinging. The first pendulum begins to lose amplitude while the second pendulum starts to swing faster and faster. At one point both pendulums swing together, with the same period. Finally, the first pendulum comes to rest, and all the energy is in the second pendulum. (1) Predict what will happen next, (2) Observe this phenomenon by means of an overhead projector, (3) What caused both pendulums to finally come to rest?

Procedure for making Lissajous figures:
(1) fill 1/4 of plastic bob with white sand, (2) punch small hole into the center of bottom of the bob and cover the hole with tape, (3) attach large eye hook to top of bob, (4) carefully tape the bob together, (5) attach a short string to the eye hook, (6) attach to the slip knot at the top of string, another string, which when slid through the knot forms a triangle 7/10's the length of the entire system; attach each end of the string triangle to a supporting rod, (7) adjust rod so that the bob hangs 3cm from the black paper covered table, (8) uncover hole, (9) set bob in motion, (10) observe the Lissajous figures made out of sand. (Experiment with colored inks, sugar, etc.)

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Acceleration

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Objectives:

To develop an understanding of velocity and to distinguish it from speed. To learn to determine the difference between a scalar and a vector quantity. To learn how acceleration is derived from velocity and time.

Materials:

Pencil, paper, adding machine tape, 1-ft x 4-ft brown cardboard, 3-ft x 3-ft brown cardboard, marking pens, paste, stick-paste, 8-ft aluminum u-angle rail, 1/2-lb ball bearing, assorted small wood blocks, assorted pieces of cardboard as shims, mechanical or electric metronome.

Strategy:

Since this lesson follows a number of other already in sequence it is assumed that the student has a certain background knowledge necessary for this lesson on acceleration. The student is reminded of certain concepts and introduced to a few new ones. The equipment is set up before class starts. The 8-ft rails are set up with one end propped up about 2 to 3 cm higher than the other so when the steel bearing is allowed to roll down the track it would take about 10 sec to roll from one end to the other. Now we start the metronome and we make a few trial runs. Then we tape a long piece of adding machine tape parallel to the rail. We mark a line on the tape next to where the center of the ball is and also put a 0 on this line. This will be our starting point for our marks. Now we start the metronome and set it for 96 clicks per minute. Then we take a marker and make a countdown starting from 3 to 0 and when at 0 we start marking until we get up to 11 or when the ball reaches the end of the rail. Then we take the tapes and cut them at each mark. After three students ran their tapes and cut them at each mark, we are now ready for the graphing.

For graph one we will plot distance vs time. Each person in the group will use his tape for a different graph. He will then decide who will use his tape and for which one (graph). Take the cut tapes and label them d_1, d_2, d_3, etc. Take the first tape and paste it on the lower left corner vertically of the cardboard graphs we prepared yesterday. Then take the second (d_2) tape and paste it with its lower left corner next to the upper right corner of the first piece. And continue pasting each successive strip until you get to the top of the graph or you get all ten strips pasted.

To do graph two the second person of each group will label their tape pieces V_1, V_2, V_3, etc. This graph plots V vs t. Paste each strip vertically starting on the bottom line of the graph and next to each other. All ten strips should fit on your graph.

Graph three plots change in velocity vs time. Cut and label the tapes V_1, V_2, V_3, etc. Then lay tape V_9 on top of V_{10} and cut off the difference. Call this delta V_{10}. Likewise place V_9 on V_8 and cut off the difference of V_9. Then do the rest of the tapes in decending order until all delta pieces have been cut. Then paste each delta piece from left to right on the bottom line of the graph.

Recordings:

After the three graphs from your group are done, you may help other groups to finish. Then measure each tape (in cm.), write these values on each tape and record them in a data table for each student. After all this the class will analyze the graphs and develop a consensus for our conclusion.

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Determining Momentum and Energy Loss of Balls Colliding Against Different Surfaces

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Objectives:

1) to relate types of material used in the construction of balls to the purpose for which balls are used in certain sports

2) to show the difference between one-dimensional elastic and inelastic collisions

3) to calculate momentum of various balls colliding against three different surfaces and to compare results with theoretical principles of conservation and energy

4) to record/graph test data to compare momenta of balls

5) to determine if water on a surface affects the conservation of energy in balls colliding against a surface

6) to apply principles of momentum and conservation of energy to the development of protective mechanisms existing in motor vehicles

Vocabulary:

collision
one-dimensional collision
elastic/inelastic collision
momentum
conservation of momentum
graphing/variables
energy
potential energy
kinetic energy
velocity
acceleration
conservation of energy

Materials:

1) various balls (see suggested list below)
2) laboratory balance
3) surfaces (wood, concrete/slate, carpet)
4) water
5) blackboard
6) meter sticks

Strategy:

Identify various balls used in playing different sports. Demonstrate the two types of collisions: elastic and inelastic.

Conduct teacher demonstration of using apparatus to determine momentum of a bouncing ball. Make use of transparency displayed on overhead projector showing basic set-up for measuring distance(d) ball bounced to a point on the meter stick. Mass the ball used in the demonstration and use the distance recorded to calculate the time and the velocity of the bouncing ball. Record results on a data chart. Determine the momentum of the bouncing ball and the potential energy lost during the collision.

Arrange students in groups of 3-4 and give each group three different balls to use for the activity. Obtain the mass for each ball and record data. Using one ball at a time on each surface, drop a ball from a given height (l m) onto a surface and measure the point where the ball bounced up to the meter stick. Use the distance (l m) and the acceleration due to gravity (10 m/s) to calculate the time (t) that it took for the ball to reach the surface. Use the time calculated to determine the velocity of the ball as it dropped to the surface. Determine the momentum of the dropped ball by multiplying it's mass by the velocity. Repeat entire process using the remaining balls, recording data carefully. Spread water on each surface and again bounce each ball, noting any change in the height (d**) recorded. Record final results for all balls on chart on blackboard.

Compare data recorded by all groups on the blackboard, noting the most elastic and/or inelastic balls. Discuss reasons why a particular ball is used in a sport. Using a transparency containing representative class data, show comparisons of data collected on the overhead projector. Discuss conservation of momentum and conservation of energy as it relates to one-dimensional inelastic collisions.

Discuss how water affects inelastic collisions against different surfaces.

Discuss the use of air bags/seatbelts in motor vehicles as safety mechanisms to reduce impact force by increasing impact time during collisions.

Suggested balls: clay, putty, rubber, ping pong, super ball, steel, golf, tennis, squash, baseball, Nerf ball (sponge)

Transparencies: general apparatus, chart with test data from three surfaces to be compared

Hand-outs: Calculation sheet with equations used to find time, velocity, momentum, and potential energy.

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Demostrations of Law of Conservation of Linear Momentum

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Objectives:

My objectives are to - (1) give a graphic demonstration of what the momemtum of an object really is; (2) review some of the more commonly available laboratroy equipment used to study momentum; (3) and produce as well as use some momentum equipment that is very simple, cheap, and easy to use.

Apparatus needed:

The apparatus consisted of an air track, air table, momentum machine, billiard balls, small rubber ball, rope, steel pipe, seltzer water, rubber stopper, two wheel chairs, and small springs.

Recommended strategy:

The first step is to establish what momentum is. This is done with a little twist of humor by telling a story of how three little boys attempt to kill a big ferocious bear by using projectiles of different size mass and different velocities. Of course only the projectile with sufficient mass and velocity is able to do the job.

From their we move on to establish what it means to conserve momentum. We first observe a stationary pipe sealed on one end and with a rubber stopper on the opposite end. The students are asked to tell what the momentum of this system is and with no exception all of them say the momentum is zero. After seltzer water is placed in the pipe the rubber stopper flies out one way and the pipe another way. The students are once again asked to give the momentum of this new system and most will say that the momentum has changed, changed to some nonzero or positive value.

We then proceed with the concept of positive and negative velocity and how the sum of the two momentums resulting from this reaction add up to zero. Hence, momentum is conserved and the law of conservation of momentum is supported.

From this point we examine some of the equipment that is traditionally used to study comservation of linear momentum: air tables, air tracks, and the momentum device. A small demonstration is performed with this equipment. I also bring out that the equipment is expensive and easily damaged. I introduce the idea of using simpler materials to illustrate conservation of momentum.

One piece of equipment consists of two balls with a spring glued to at least one of the balls. You use both balls to compress the spring about one meter directly above a point on the floor. Very quickly you release the balls. Both balls should have equal momentum. If they are of equal mass then they should have equal velocities which will lead to to them landing equal horizontal distances from from the point on the floor. If they are of unequal mass they will still have the same momentum but the more massive ball will have a smaller velocity the less massive ball. This results in the more massive ball traveling a smaller horizontal distance than the less massive ball. The results for this experiment don't give good quantitative data but the results do produce qualitative data that is good enough to support the point.

Another demonstration involved three momentum carts of equal size. One of the carts is securely taped on top of another cart. The result is two carts, one which is roughly twice the mass of the other cart. A spring is placed between these two carts to propel them in opposite directions. Because of the law of conservation of momentum, we can assume that both carts will be given equal momentum. We can also assume that the velocity of the lighter cart will be exactly twice the velocity of the heavier cart. This is the only way two masses, one which is half the mass of the other, can have equal linear momentum. If the velocity of small cart is twice that of the larger cart then the small cart should be able to cover 2 times more distance in any given period of time. We place a block of wood some arbitrary distance, say 2 meters, from the smaller cart and another block of wood one half of former distance, 1 meter in this case, from the larger cart. Both carts should arrive at their finish lines at the same time. It will be clearly observable to the students when the carts crash at the same time. This experiment works very well to be so simple in design.

A third experiment involves the use of wheel chairs. Two students, one much larger than the other, face each other seated in the wheel chairs about about 15 to 20 feet apart while while holding the opposite ends of rope. Before they start pulling they have a total momentum of zero. To maintain a state of zero momentum after they start pulling the larger student will move at a smaller velocity and, therefore, not travel as far. The smaller student will move at a much higher velocity and, consequently, roll for a greater distance. It is important that the wheels of the wheel chair be aligned correctly before the pulling starts and that some one be there to catch the students before they crash in to each other. There are a lot of variations that one can do with this. Two students of similar size can pull. Students can push off of each others hands instead of pull. The results will probaly not be good enough to make good quantitative measurements but they will be quite sufficient for making a qualitative estimate of what should take place.

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Centripetal Force

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Objectives:

To illustrate the components that govern the size of centripetal force in an object that moves in a circular path around a central point.

Apparatus needed:

Small glass tube (polished ends),2m of fishing line, rubber stopper (#5),paper clips,10-1/4 of an inch washers,and a timing device with a second hand.

Recommended strategy:

Attach one end of the fishing line to the rubber stopper and pass the other end of the line through the glass tube. Then tie the other end of the line to one of the paper clips.This device we will call our centripetal force apparatus.It should look like the following;

```
  STOPPER      ------->     ////////I
                          //        I
  _______________________I          I
I I I                    I          I
I I I                      \\       I
I I I                        \\\\\\\I
I I I
I I I
I I I  <--------GLASS TUBE
I I I
I I I
I I I
I I I
I I I
  I
  I
  I
  I
  I
  I <--------FISHING LINE
```

```
                 I
                 I
                 I
            _____I_____
           I          I
           I          I  <-----WASHERS
           I          I
           I__________I
```

The procedur to be used is to swing the stopper around your head at a constant rate of speed and parallel to the floor.While this happending others in the group count the number of revolution that the stopper makes in a 30 second period of time.This should be done using groups of washers as counter weights of 6,8,&10 each done for three trials.At the conclusion the group should be to plot a graph of velocity square vs radius (of the circle that the stopper moved in).There should be some discussion concerning the effects of how as the number of washers & radius of rotation changed the effects on the number of revolutions per second.

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Flight Physics

Group Mini Teach
Antoinette Rabalcaba
Loretta Rich
Renee Russell
Eric Skalinder

Objectives:

Familiarize students with forces influencing a body in flight
Introduce **Bernoulli's Principle**
Construct simple types of aerodynamic designs

Apparatus needed:

two 8" X 11" sheets of paper
one half sheet of paper
cut outs - simple gliders
scissors
paper clips
scotch tape

Recommended Strategy:

A. History - Man's interest in flying examples and living visual aids
B Forces affecting an object in flight (transparency)
C. Balanced Forces
D. Bernoulli's Principle Blow on top of 1/2 sheet of paper to observe lift.
E. Construction of simple falling bodies
   1. The Control Drop a sheet of paper to the floor. Observe its flight pattern. What forces influence the paper?
   2. Construct a cone and drop it to the floor. Observe its flight pattern. What forces have been overcome by the cone shaped nose?
   3. Take one sheet of paper and fold one horizontal end over end five times, press flat, and secure the three paper clips (one clip at the center and the other two clips at 3-4cm from each edge). PAPER WING.
   4. Drop PAPER WING to the floor and observe its flight pattern Use fingernail and thumb too curl edge opposite clips on the paper wing. Drop paper wing to the floor and again observe the flight patterns. Fold and crease to the center open and drop the paper wing again make observations. Next fold up edges to make rudders and drop again.
   5. Parts of an airplane functions (transparency)
   6. Construction of simple aerodynamic structures Wing and Dart

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pass out cut outs, scissors
test gliders and determine the best designs based upon
the forces which control successful flight
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CONSERVATION OF MOMENTUM

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Objectives:

1) To use a memorable example of an explosion to impress the fact of Conservation of Momentum.
2) Using the Conservation of Momentum, determine the velocity of the tennis ball as it comes out of the tennis ball cannon.

Materials:

1) One tennis ball, new ones work better than old ones.
2) One tennis ball cannon. Directions for construction appear at the end. It must be made out of steel cans, aluminum ones may blow up in your face!
3) Lighter fluid
4) Some matches, and some wooden splints.
5) A photocell timer to time the recoil of the cannon. (optional, but probably the most accurate means of determining the times and velocities.)

Strategy:

1) What?
   Get their attention! With some fluid in the cannon, shake the cannon,place the ball in the front and fire. (Be sure you aim at a solid object,not the windows etc.)
2) Propose the problem:
   What is the velocity of the tennis ball as it leaves the cannon? How are we going to find out? What kinds of measurements can we make to give us the information we need to determine this velocity?

   At this point in the year your students should have several methods to propose:

   Velocity = Distance/Time

   So, if you can time the tennis ball over some measurable distance, you have it made.
3) How:
   Demonstrate the timer: Show that it times in thousandths of a second, while the beam is obstructed.

   Fortunately for the point here, for a memorable shot the tennis ball moves too quickly for an accurate timing. (Somewhere between one and two thousandths of a second for its passage past the photocell.) In order to use the timer we must time the recoil of the cannon and then use Conservation of Momentum to determine the velocity of the tennis ball.

   On the board write the equation for the Momentum in this explosion:

   0 =(Cannon Mass)(cannon velocity) + (Ball Mass)(velocity of ball)

   Ask your students
   "What information will we need to find the velocity of the ball?"

They should mention the masses,and the length of the cannon, and the time that the cannon takes to go past the photocell.

2

Assign each of these tasks to a different student. Record this data in its location in the formula.

Set up the timer in a convenient location. I go out in the hall, this allows you a long range for firing, and lets all the other science students to notice your existence!.

Warn your fellow teachers, if you wish, and send a student down the hall to retrieve the ball.

The cannon should be loaded with fuel, shaken up, then loaded with the ball and placed so that it will roll backwards through the photogate as it fires. Be sure to zero the timer before firing!

Light a splint, and hold it to the hole at the back. With any luck, it will fire!

Record the time. Return to class, place it in the equation and calculate the velocity of the tennis ball.

If you have recorded the length of the cannon in meters, this will give you a velocity in meters per second. Have someone convert this to miles per hour -- the students have a much better feel for this, and should be impressed. 60 mph is fairly typical of a good shot, the Thornwood HS record is 109 mph.

Advice:
Be sure that you discuss the safety involved here.
The cannon must be steel!!!!
Impress your students that aluminum will not work, and will probably send bits of aluminum shrapnel into their face.

If the ball does not fire, remove the ball, add some more fluid, and shake. Concentrate on forcing air into the cannon as you shake. This is especially important if you have had a previous shot.

Your students will probably want to fire the cannon again. I usually do, if you choose to do so, assign the task of remembering the time for the first firing to a nearby student. Remember to zero the timer before firing again.

Making a cannon of your own:

You need three or four cans made of steel. The cans should have an inside diameter of 2 and 9/16 ths of an inch. It is possible that this could be 1/32 in larger, but a reasonably tight fit is important.

With the tops out of two cans, use a bottle opener to punch holes in the bottom of one of these cans. With a nail, punch a hole in the side wall near the bottom of the other. Tape the open ends of these two cans together. These compose the fuel chamber.

Cut the tops and bottoms out of the other two cans. Tape these cans together, and tape them to the bottle openered end of the fuel chamber. These make up the ball chamber. Tape all four to a set of wheels. Be sure the nail hole faces up. It may be useful to tape a stiffening bar to the top of all four cans to keep them from sagging.

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WORK,POWER AND ENTROPY

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OBJECTIVES:

1:To demonstrate, explain and allow the student to experience work and power. 2:To allow the student to observe that entropy is a real process that must occur whenever work occurs.

MATERIALS:

For part B. Meter stick, chain (about 2 meters), double pan balance, stop watch.

For part A.Jar that can be sealed (gallon condiment jar), 50 ml beaker, support to hold beaker close to top of jar, distilled water, dehydrating agent, analytical balance.

STRATEGIES:

```
                   ----------------------
                   |  Display jar with  |
                   |  beaker and liquids|
                   |  tell students to  |
                   |    observe jar.    |
                   |____________________|
                   __________|___________
                  |  Record observations.|
                  |______________________|
                   __________|___________
                  |  Explain that jar is |
                  |  an engine .         |
                  |   (pumping water) .  |
                  |______________________|
                   __________|____________  ____________________
                  | Ask for definitions  |__|    Record        |
                  |     of work .        |  |  definitions.    |
                  |______________________|  |__________________|
                  ___________|____________
                  |    Define work.      |
                  | Work=ForcexDistance. |
                  |______________________|
              _______________|_______________
              | Have students do work.      |
              |  Build apparatus.(Beaker in |
              | jar,record masses,etc.)     |
              |_____________________________|
               ____|____        ____|____
               |       |        |       |
               | Part A |       | Part B |
               |________|       |________|
                    |                |
 ________   _________|_______   _______|_________   ___________
 |Record |  |   Build       |  | Lift masses,  |  | Record    |
 |masses,|__| apparatus     |  | same height,  |__| mass,     |
 | time, |  | (beaker in    |  |different times|  |distance,  |
```

```
  |  etc. |  | jar,etc.)   |  | (triplicate)  |  |   times. |
  |_______|  |_____________|  |_______________|  |__________|
2
 __________    _____|__________ _____|_____    ____________
| Graph:  |__ |     Calculate work.        |___| Graph:     |
|Force vs.|   |____________________________|   | Force vs. |
|distance |    ____|____    _______|_______    | distance  |
|_________|   | Define: |   | Was work same|   |___________|
              | Power=  |   | in each case?|
 __________   |work/time|   |  HINT-NO     |
| Graph:  |__|_________|   |______________|
| Work vs.|       |          _____|________    _________
| time    |       |         | Define:     |__| Graph:  |
|_________|       |         | Power=      |  | Work vs.|
                  |         | work/time   |  | time    |
                  |         |_____________|  |_________|
             _____|_______________|________
             | What caused work to occur  |
             |     in each case ?         |
             |   (ENTROPY CHANGE)         |
             |____________________________|
              ____________|_______________
             | Introduce   entropy.       |
             | Disorder has increased.    |
             |____________________________|
```

DEFINITIONS: WORK=(FORCE)(DISTANCE). Joule=Newton meter.

POWER=WORK/TIME.   Watt=Joule/second.

ENTROPY = the disorder in a system. Entropy always increases when work is done.

ADDENDUM: These topics were chosen as a group for two reasons.

A. In common language we confuse work and power; (many times what is considered "hard Work" or "working harder" is really equal or less work but greater power). Therefore we attempt to clarify these concepts.

B. To introduce the concept of entropy (work cannot occur without an increase in entropy).

BACKGROUND: Before introducing this experiment the students usually will have mastered simple machines (levers, pulleys, inclined planes, etc.). The minimum knowledge required by the by the student to be at ease with the experiment is:

A. multiplication and division,

B. graphing.

This experiment can then be mastered by students in intermediate grades. The calculus presentation would be appropriate for better prepared high school students or college students taking physics for the first time.

TIME REQUIRED: Part B can be completed in a class period (about fifty minutes).

Part A needs long periods of time to complete; but only a few minutes each day after the initial set up. In part A the work is caused by diffusion of water from a lower level to the dehydrating agent which is at a higher level. The beaker of dehydrating agent plus water need be massed (weighed) occasionally (about every two days) for at least a month. This massing will take only a few minutes each time. This part of the experiment is critical to explain entropy. EXPLANATION: In

Part A the student will learn the difference between work and power.

As a phenomenological experiment they will see that something is the same in each case (work); but that something else (power) varies.

At the intermediate level very good students should be able to deduce the difference.

At the intermediate level the student should learn:

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WORK = (FORCE)(DISTANCE); the unit is, JOULE = (NEWTON)(METER). The newton (which is a unit of force) can be determined using a newton scale; or by massing an object on a balance (grams) and then multiplying by the acceleration of gravity (9.8 meter/second^2).

POWER = (WORK/TIME); the unit is WATT = (JOULE/SECOND).

At the high school level a presentation with problems similar to that in, "Physics,Principles and Problems", Murphy and Smoot; Charles E. Merrill Publishing, 1977. Teachers Edition, 1977; pg 139-142; will be convenient.

At a more advanced level "PSSC Physics, Fourth Edition," Haber-Schaim et al, D.C. Heath and Co. 1976. Pgs 326-328; will be appropriate.

At the calculus level a text like Resnick and Halliday would be used.

CONCLUSION: As Part B progresses it should become apparent, by analogy with Part A, that work is being done and power is being expended (albeit in very small amounts). The phenomenon to be observed in B is:

"What causes the work to occur?"

In A it was the muscles of the student, food, etc.

In B the cause is the decrease in concentration of the dehydrating agent. This decrease in concentration is entropy. The dehydrating agent which was "pure" is now diluted by water; it is now "impure". The disorder has increased. This increase in "disorder" (entropy) has caused the work to occur. The work will continue until the dehydrating agent reaches the same concentration as pure water (forever). By similar logic "increased disorder" (entropy increase) caused the work to occur in Part A.

Therefore:

A.whenever work is done entropy is increased,

B.the greater the power the faster entropy is increased.

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THE CENTER OF MASS

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GRADE LEVELS: Grade 7 and 8

Objectives:

1. To determine the center of mass of two irregularly shaped objects.
2. To determine when the center of mass is inside the boundaries of the object and when the center of mass is outside the boundaries of the object.
3. To determine when an object is stable or balanced or why an object is unstable or unbalanced.

Materials: 8-multi-speed cars
10-forks
10-spoons
10-plastic cups
10-irregularly shaped object cards
10-strings
10-rubber washers
10-nails
1-Leaning Tower of Pisa
1-double cone, cylinder and incline
1-styrofoam center of mass fish
1-3.81 cm metal sphere
10-boxes of colored chalk
10-Q-tips

Strategy:

Opening: Toss a metal sphere across the room; it travels a smooth path or parabola. Then toss the styrofoam fish across the room; it does not follow a smooth path. It wobbles all over the place except for a very special place we are going to discuss today. We are going to talk about the center of mass.

1. Where is most of the mass of the fish concentrated?
2. Look at the two lights as the fish is being tossed through the air. Does the path of either light form a parabolic curve?

Discussion: The center of mass is the average position of all the particles of mass that make up a particular body or object. The metal sphere is a symmetrical object and its mass is concentrated at its center. In contrast, more of the mass of the fish is concentrated toward the head of the fish. Therefore, the center of mass of the fish is toward the heavier end or the head of the fish. When we toss the fish it does wobble all over the place. However, one of the lights does follow a parabolic path. We used this light to mark the center of mass of the fish.

Activity: Slide a nail through one of the two holes in the object. Slip the string over the opposite end of the nail and let it swing freely using the washer to weight the string. Chalk the string letting it mark the straight path, from the point of suspension to the opposite end of the card. Then repeat these same steps with the second hole in the object. The center of mass will be located where the two chalked lines intersect. The center of mass can be checked by placing the eraser of a pencil at the point of intersection and see if the object balances on the pencil.

1. Why does the object swing back and forth when placed on the nail?
2. Where is most of the mass of the object concentrated?
3. Is the center of mass of the object within the boundaries of the object?

Discussion: (Sketch two L-shaped figures on the board.)

Figure a Figure b

If we drop a line straight down from the center of mass of a body of any shape and it falls inside the base of support, as in Figure a, it is in stable equilibrium and the object will be balanced. However, if the center of mass falls outside of the base of support it is unstable and will not be balanced, as in Figure b. In our irregularly shaped object, the center of mass is within the boundaries of the object.

Activity: Stand against the wall and try and touch your toes.
1. Where is your center of mass when you lean forward to touch your toes?
2. What is the base of support for your body?
3. Is your center of mass inside or outside your base of support?
4. Why does your body rotate* forward?

*The rotation of your body as you move forward is called torque.

Then stand away from the wall and try to touch your toes.

1. After you move away from the wall, where is your center of mass?
2. Is the center of mass inside or outside your base of support?
3. This time the body does not rotate forward. Why?

Discussion: You can lean over and touch your toes without rotating forward only if your center of mass is above the area of your base of support. In this case, your base of support would be your feet.

Activity: Determine the center of mass of the multi-speed car. Once you have found the center of mass, select your car's speed. Then joining forces with another team, leave one car stationary and run the other car into one side of the front end of the stationary car. Then run your car into the rear of the same side of the stationary car. Finally, run your car into the center of mass of the stationary car. Determine what happens in each case.

1. Where is the center of mass of the car?
2. When the stationary car is hit in the front, of one side, in what direction does the car move?
3. When the stationary car is hit in the rear, of one side, in what direction does the car move?

Discussion: The center of mass of the car is a few millimeters in front of the rear wheels. When the stationary car is hit in the front, the car moves counterclockwise denoting a counterclockwise torque. When the stationary car is hit in the rear, the car moves clockwise denoting clockwise torque. When the stationary car is hit at the center of mass, the counterclockwise and the clockwise torques are equal. The net torque is equal to zero and there is no rotation. The stationary car is just pushed forward. In relation to the moving car, they are perpendicular to one another.

Activity: Fasten a fork, spoon, and one Q-tip together as shown below:

3

The combination will balance nicely on the edge of a plastic cup (it may be necessary to weight the cup).

1. Where is the center of mass for the whole setup?
2. Would this work if the Q-tip were shorter?

Discussion: It is possible to balance this combination on the cup because the center of mass is somewhere below the point of support. The heavy handles of the fork and the spoon curve toward the cup. This shifts the center of mass of the entire structure to a point directly beneath the spot where the Q-tip rests on the cup, putting the fork, spoon and Q-tip in a state of stable equilibrium; it is balanced. This will work with a shorter Q-tip. However, the Q-tip will have to be long enough to rest on the rim of the cup and have some of the Q-tip overlap.

Demonstration: I have two objects I would like to demonstrate. I want you to consider everything we have covered up to this point. After the demonstration I would like you to explain how you think each object works.

1. **Leaning Tower of Pisa:** When the top is removed, the center of mass of the Leaning Tower of Pisa lies above a point of support, and therefore the tower is in stable equilibrium. When the top is added, the center of mass is outside the base of support. The Tower is unstable so it topples over.

2. **The Double Cone and Incline:** When the cylinder is placed at the top of the incline unrestricted, gravity causes it to roll to the bottom, down hill. However, when the cone is placed on the incline it appears to roll up hill defying the law of gravity. The center of mass of the cone is concentrated at the center of the cone and the cone tapers as you reach the ends. When the cone is placed at the bottom of the incline it is placed there at its center of mass. The center of mass always seeks the lowest position it can reach. The track of the incline widens permitting the center of mass of the cone to be lowered. This allows the cone to reach a more stable position. To reach this stable position the cone rolls up hill.

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MEASURING THE GRAVITATIONAL CONSTANT, G

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BEHAVIORAL OBJECTIVE:

Students will see that the gravitational force is indeed universal; The gravitational force acts not only on, but also between objects of normal size and mass. Advanced students will measure the proportionality constant G which appears in Newton's expression for the gravitational force acting between two spherical objects.

MATERIALS:

A large Cavendish or torsion balance was constructed; Bags of sand (nominal mass 27 kg) acting on 0.3 kg end masses provide the torque. The torsion fiber is a stainless steel wire with a diameter of 0.003 inch (0.0012 cm) and a length of approximately 1.75 m. The lever arm of the balance is approximately 0.9 m. A large frame was constructed of wood and enclosed with plastic windows. Aluminum window screen was used to control electrostatic forces acting on the end masses. The torsion bar was a piece of aluminum edging (of the sort used to encircle kitchen sinks) obtained from a local hardware store.

STRATEGY:

When students study the gravitational force in the usual manner (Kepler's Laws of Planetary Motion are presented as empirical deductions from data; The nature of the required force is deduced from the centripetal force law and Newton's Third Law), the instructor is normally forced to make two concessions which are directly contrary to the phenomenological approach to teaching. First, he must make the unsupported assertion that the law derived from planetary data is "universal," and can be applied to any two objects, including those of ordinary size and mass. Secondly, the instructor must provide the value of the constant G which appears in the Newtonian expression. Since the treatment of gravitation usually occurs in the middle of the first semester, shortly after the students have finally begun to appreciate the phenomenological approach to physics instruction, the traditional treatment runs contrary to the phenomenological teaching philosophy.

An alternative strategy which is consistent with the phenomenological approach would be to provide at least a demonstration of the universality of Newtonian gravitation by showing that objects of ordinary mass do in fact attract one another with a force which cannot be attributed to other causes. It should be possible to extend the demonstration to include actual measurement of the gravitational constant, though this could (and perhaps should) be reserved for advanced students or special projects. Apparatus to accomplish this objective is commercially available. Unfortunately, the cost is prohibitive in the light of most public school budgets. Thus, an attempt was made to build a large-scale version of the traditional torsion balance apparatus which would be economically feasible and provide a clearly visible demonstration of the gravitational attraction between objects of ordinary mass. Drawings and a complete list of materials used are available from the author.

In practice, the torsion balance is allowed to come into equilibrium with the two bags of sand "kitty-corner" from each other, as shown in the diagram. Once equilibrium has been achieved with the sand bags in this position, the bags are

carried to the other end of the apparatus and a new equilibrium position is determined. The change in equilibrium position shows the existence of the force.
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The dimensions of the apparatus were chosen to make the actual displacement of the end masses as large as possible. Permanent records of the original and final positions can be made by placing a sheet of graph paper over the top window and recording the point directly over the lever arm at each of the two equilibrium positions. This approach will not result in data precise enough to allow a measurement of G.

To make the demonstration quantitative, a more precise method of measuring the angular displacement between the two equilibrium positions must be used. At present, the author has not attempted to improve the apparatus to include such measurements. Usually, an optical lever is used, though Cavendish himself used ordinary ruled markings.

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VECTORS

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OBJECTIVES:

To define a vector and its rules. To use as a tool to help clarify its use with motion and forces. To have students discover these relation-ships with the use of various simple equipment and a computer.

MATERIALS:

Three pieces of heavy yarn of different colors, preferably blue, orange, and green. Three pieces of chalk of different colors, blue, orange, and green. A large blackboard protractor. Several meter sticks and 2-meter meter sticks. Three bricks wrapped in plastic. A side clamp for the front desk. A computer with a large monitor. Four large pieces of paper with E,W,N,S printed on them.

STRATEGY:

Post the four large signs representing the directions on the four opposite walls in the classroom before class begins. Ask a student to move a brick from the front desk to his seat. Make it known to the class the direction that the brick was moved and that it might represent the change in position of any object from one position to another. Ask the class to enter into the description of this change in position of the brick (to elicit an answer of "displacement"). Have students take out a sheet of paper and pencil to record a simple data table you place on the board, having length in meters and angle in degrees for each of the three sides of the triangle. Label the sides A,B,C respectively. Also the angles are labelled as alpha, beta, and gamma. Ask those students with calculators to raise their hands, then divide the class into groups of three or four people so each group would have access to a calculator. Challenge each group to find one of the sides and angles, then record them on the board. Then graphically have the students record them on their graph paper. Show students how to graphically add vectors "head to tail", by putting the head of the second vector to the head of the first vector and so forth until all vectors for that problem have been added. While writing vector equations remind the students to indicate above each algebraic symbol a small arrow representing a vector.

After graphing, a chalk and talk review of vectors takes place. At this point the students would be advised to record these notes for future reference. The main concepts revealed here were the addition of parallel vectors (positive or negative) depending on their direction, then adding two vectors at 90 degrees was shown. A third but more realistic way to add vectors at any direction (not 90 or 180 degrees) was also shown. Here we introduced the use of the Law of Sines.

For another class period an interesting computer review was prepared for the students with a dialogue on the computer and displayed on the large monitor. There were several parts to the dialogue. The student takes out a paper and pencil and writes down the answers to the definitions asked for on the first part of the dialogue. A student is asked to operate the computer at the teachers' command. The best answer on the monitor screen is not revealed until the definition is rather thoroughly discussed. The computerized review of the problems are revealed step by step on the monitor with the students recording it. The problem is broken down step by step and reconstructed with complete agreement on each step along the way. First a problem involving parallel vectors was used and repeated a number of times. Then the vector problems using right angles was reviewed. The vectors at

various angles were shown to be quite simplified by using this method. A ditto sheet is then passed out and a few "homework" problems are printed on it to review
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them. With the use of the computer monitor we substituted some of the homework problem variables in it and proceeded to demonstrate to the students how to solve the problems by breaking them down into steps and reconstructing them.

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FRICTION

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OBJECTIVES:

To study the effects of friction in a simple mechanical system.

APPARATUS:

1) Self propelled dynamics cart (coil spring driven)
2) Meter stick
3) stopwatch

Procedure:

1) Perform "Hookes Law" experiment for coil spring constant
2) Determine distance and time for PE transfer
3) Calculate KE transfer for
    a) Translational KE
    b) Rotational KE - wheels, pulleys, axles
4) Determine the efficiency of the system

Calculations : Determine the difference in energy levels using KE formulas for energy of translation and rotation. The ratio of kinetic energy of the cart to the potential energy of the spring will yield an efficiency value for the system.

Conclusion : In most first year physics courses energy lost to friction is traditionally ignored. Through this activity the observation can be made that a significant (80% - 90%) of the system energy is lost to frictional forces while doing useful work.

Extensions / Modifications :

For translational KE only keep the ratio of rotational mass to translational mass small.
example - small wheels - light wheels - single pulley - added mass to cart.

For non-uniform motion - the cart will accelerate at rates dependent on the coil spring constant and the selected step pulley. To study these rates a timer tape can be attached to the cart to determine varying rates of motion.

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The Bernoulli Effect - Conceptually

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Objectives:

Simply doing and/or observing the experiments (below) should excite the intellectual curiosity for people of all ages. Here is a rough guideline for what might be expected.

Grades K-5: Students should be able to describe at least two of the experiments orally and –- subject to your judgment –- in writing.

Grades 6 –9: Expect students to describe two or more experiments both orally and in writing, and to explain their observations in terms of simply stated Bernoulli Effect:

Where the velocity is high, the pressure is low, and where the velocity is low, the pressure is high.

Grades 10-12: Students should explain observations conceptually and mathematically beginning with an algebraic statement of the Bernoulli Effect.

Materials:

Students:

Experiment 1

These items are usually available at grocery stores.

- Soda straws (one straw cut in half for each student plus a few extra)
- Small paper or plastic cups (a few more than one for each student)
- A regular (2.5 gallon) pail 2/3 filled with water
- A sponge and roll of paper towels
- Vegetable dye

Experiment 2

- Paper – 8.5 × 11 sq. in. – enough for each student to have a sheet. Should not have folds or wrinkles, but may be “used” otherwise.

Teachers:

Experiment 3

- A dime
- A transparent jar or beaker (at least 500 ml)

- A smooth, flat tabletop

Experiment 4

- A wood or plastic spool for sewing thread (it is okay if it still has thread)
- A paper clip
- A piece of paper or light cardboard about 2×2 inches
- A piece of brightly colored heavy yarn 12 to 18 inches long.

Experiment 5

- An electric leaf blower. One with a variable speed is a plus. Its blower tube should have a diameter of 2 to 3 inches, and a length of about 2 feet.
- A hollow rubber ball with a diameter of 2 to 3 inches
- A piece of brightly colored heavy yarn (see experiment 4).

Strategy:

The main idea is to do several different experiments, each time connecting specific observations with the simply stated Bernoulli Effect. This enables students to make the connection in their minds from a variety of concrete, specific observations to the abstract generalization known as our simply stated Bernoulli Effect.

Begin with Experiment 1 materials at hand placed on or near a table at the front of the room. .Hold up one of the small cups and tell your students that you want to show them something, and you would like them try it. Fill the cup nearly full of water by dipping it into the pail. Add several drops of vegetable dye (red, blue, green work well) and stir with a half straw. Hold the cup level with one hand, and - with the fingers of the same hand - hold a half straw vertically so that its bottom end is immersed in the water and its top end is about 1.5 inches above the water's surface. Using your other hand, hold another half straw to your lips so that you can blow through it. Hold the cup so that you can blow a stream of air perpendicular to and across the top of the immersed half-straw. Stand sideways to your student audience and then blow strongly through the straw.

Water will rise up to the top of the immersed straw where it will be broken up into a spray of droplets by the air stream. You have made an "atomizer", somewhat like the rubber bulb operated perfume bottles of years ago. You probably will have to practice a bit to make it work and you should practice in private before you show your students. (You need to have confidence in what you are doing.)

Now invite the students up to each get a cup, etc. so they can make their own atomizers. You probably will want to have the sponge and paper towels handy. Small cups limit the amount of water to sponge up when accidents occur.

After most students have made their atomizers work, get their attention, and ask, "What happens to the water in the immersed straw when you blow across the top?

Almost certainly a student will respond that the water rises up in the straw. For those who are not sure, repeat the experiment with your atomizer, and point out to them how the water in your straw rises up as you blow across its top. (If you have dyed the water in your cup dark enough, it is easy for students to see.)

Now you should ask them why this happens. After getting their input and discussion (which should be given your rapt attention), print on the board the simply stated Bernoulli Effect. Point out that it applies to fluids such as air and water, and then connect any of their statements that may be pertinent to the simply stated Bernoulli Effect. When you do this, illustrate the places of lower and higher (atmospheric) pressure with a simple sketch on the board that includes the air stream. Use a large arrow or two pushing down on the surface of the water in the cup, and a smaller arrow pushing down at the top of the straw. The speed of the air over the water in the cup is low (zero), so the pressure is high (atmospheric), while the speed of the air over the top of the straw is high, so the pressure there is low (less than atmospheric).

It's a good idea to ask your students to come forward to dump the water from their cups into the pail. You probably will want them to keep their cups and straws to take home to show to parents and siblings.

You might ask if they can think of any practical applications of the atomizer besides perfume sprayers. After their input it may be good for you to point out that the carburetors in gasoline engines work exactly the same way to atomize liquid gasoline and mix it with air to form the vapor that is taken into the cylinders and ignited. The expanding gases then act on the pistons to make the car go. Can you think of others?

Experiment 3 probably is a good one to do next, so clear any clutter from the table at the front of the room and have the materials for this experiment on the table.

- It is very important to practice this ahead of time, so that you know you can do it with the particular table and coin (dime) you will use.

With your student audience facing the front of a table, stand at one side so they will be able to see clearly what you are doing.

Place a dime in the clear glass container. Hold it up and shake it around so everyone can hear the clinking of the dime against the glass. Then dump the dime out into your hand, hold it up for all to see, and place it on the table in front of you. Usually 6 to 10 cm from the edge of the table works well.

Now challenge your students. Ask if anyone can move the dime into the beaker without touching the dime with any object or moving the table. After getting their input, you are ready to show them how to do it.

With the beaker on the table behind the dime (from your perspective), tip the beaker so that the bottom edge of its opening is 1 to 2 cm above the table surface and about 6 to 10 cm behind the dime.

Place your lips just above the edge of the table, in front of the dime (you probably will have to kneel on the floor to do this) and then blow a strong puff of air across the top of the dime. It will jump up into the air stream and travel with it into the beaker with a clinking sound. (Practice until you can do it! If it is difficult to kneel, consider using any kind of elevated surface on the table top, like a cardboard box that will be a convenient height for you. When you do this in front of your students, if it doesn't work the first try to two, point out to them that it is tricky to do, and continue until it works. If your students get restless, invite a volunteer up to try.)

Hold the beaker up for everyone to see and shake it so that they can hear the dime clinking on the glass.

Repeat the experiment once or twice more. This is always important; observers need to confirm their first observation and make certain of what they observed. If time permits you may wish to let them try with their own cups and dimes or you might suggest they try this at home with the cups you have given them.

As you did with the atomizer experiment, it is important to help students connect their concrete observations with the abstract, simply stated Bernoulli Effect. Always use a simple sketch at the board. Show the dime on the table (leave a narrow space between dime and table), the puff of air over its top and the tipped beaker behind it. Ask "Where is the pressure low?" Perhaps the students will identify the region over the top of the dime. But the answer to "Where is the pressure high?" (under the dime) probably will require some explanation from you. You may explain that layers of air, even though only hundreds of molecules thick, exist on all surfaces that we can see and they form a thin layer on the bottom of the dime and the table. They are part of the atmosphere and are at atmospheric pressure. Since the speed of the air under the dime is low (zero), the pressure there is high (atmospheric). But the speed of air at the top of the dime is high, so the pressure is low (less than atmospheric). Drawing a large arrow acting up on the dime and a small arrow acting down will help to show that the dime will be raised up by the pressure difference. This sketch forms a picture in the student's mind to help make connections between the concrete and the abstract.

Next, clear the table and place the materials for Experiment 4 near the rear edge of the table.

Hold up the various materials and name them so the students know what they are. Place the paper clip flat on the table and straighten one segment so that it points straight up. Then use it to poke a hole through the center of the 2 in. × 2 in. card. With the straightened segment sticking up through the card, apply a short piece of sticky tape to attach the paper clip to the card from below.

With the card lying flat on the table, place the thread spool on top of the card with the hole along its vertical axis enclosing the vertical part of the paper clip. Now blow strongly and steadily through the hole at the top of the spool, and raise the spool up off the table while doing so. The card will stick to its bottom end until you stop blowing, and then it will fall off! Do this several times. Ask the students why this happens. (You may want to explain that the purpose of the paper clip is to keep the card from slipping sideways out of the air stream at the bottom of the spool.) In order to convince them that you are not sucking air up through the hole instead of blowing air down through it, you can puff your cheeks out as you blow. Then point out that you could not do this if you were sucking air up. Ask them to try sucking air into their lungs with their cheeks puffed out, and they will understand.

In order to dispel any remaining skepticism, holding a piece of yarn in the air stream may be convincing.

Ask them to explain why the card sticks when you blow into the spool. After listening carefully, make a sketch on the board, showing the spool with the card below and a narrow space between. Draw arrows showing the path of the air from the top of the spool to the card below. When the air strikes the card below, it changes its direction and moves radially outward (horizontally) in the space between the spool and the card. The pressure is lower (below atmospheric - a small arrow pushing down) where the speed of the air over the top of the card is high, and pressure is higher (atmospheric - a large arrow pushing up) where the speed of the air is low (zero). The pressure difference supports the card against its weight, which pulls down, so the card "sticks" to the spool.

If you are able to provide enough spools, etc., and if time allows, would it be a good idea to ask your students to do this experiment? Would it be a good idea to let them discover for themselves that the card sticks when they blow air through their spool?

is next, with the leaf blower. You will want the yarn within easy reach, perhaps in a pocket, and the ball nearby on the floor. What follows may well be done on a tabletop if you are tall enough. I have always done it on the floor in front of the table. And of course, you should practice this so you know exactly what you are going to do and that it works.

With the leaf blower plugged in and resting on the floor, hold it by its tube and point it so it will blow air vertically straight up. Then turn it on (at its lowest speed). Place the ball in the air stream and release it so that the ball "floats." Steadily increase the speed of the air to its maximum, floating the ball to a higher altitude above the opening of the air tube. Then decrease the speed to a minimum, so the ball descends to its lowest altitude again. Turn off the blower and ask, "What held the ball up?"

Most students will give the obvious answer that the force of the air stream held it up against its weight pulling down. To which you may respond, "Let's see."

Again, place the ball in the vertical air stream at its lowest speed. Gradually increase the speed to its maximum. Now gradually tilt the blower from the vertical toward the horizontal. Be sure you are aiming the blower parallel to the front of the table, perpendicular view of the students. (Don't blow air at the students.) When you have reached an angle of perhaps 60 degrees from the vertical (prior experimentation will help you determine how great you may make the angle before the ball falls to the floor), stop and allow the students a few seconds to observe that the ball is still suspended in the air stream, then move the tube with air stream and floating ball back to the vertical, lower the air speed to minimum and shut off the blower.

You may now ask, "What held the ball up? If the air stream were just pushing on the ball when it is at an angle, why wouldn't the ball be pushed away and out of the air stream so it would fall to the floor?"

After getting student responses, make a sketch on the board showing the blower and air stream at an angle and the ball suspended in the stream. Draw an arrow to show the ball's weight pulling down and label it with the letter W.

Next, repeat the experiment with the ball suspended at an angle in the air stream. Now hold the piece yarn (about 8 to 12 inches long) in your other hand and move your hand so that the yarn is at the top of the ball. The air will blow the yarn so that it stretches out to show the direction of the stream. Now move your hand to follow behind the ball and directly below it. The yarn will hang limp because the air stream below the ball is not strong enough to support it. Do this several times, top of ball to just under the ball. It will become evident that the speed of the air over the top of the ball is great, while its speed across the bottom of the ball is small.

Restore the system to rest, as in two paragraphs above. Make another sketch of the ball suspended in the air stream but this time locate the ball lower in the air stream, so its bottom actually lies below the line depicting the lower boundary of the stream. Ask, “Where is the air speed high?” And when the students tell you at the top of the ball, draw an arrow in the direction of airflow at the top (which is at about 60 degrees from the vertical) and label it “high speed.” Ask, “Where is the air speed low?” -- and draw a very small arrow at the bottom of the ball. Then draw a very small arrow (preferably in a different color, and pointing downward and perpendicular to the air stream) to show the force from small pressure at the top. Label it P-top. Then draw a larger arrow (same color, pointing upward and perpendicular to the air stream, labeled P-bottom) to show the larger pressure at the bottom. Point out the agreement with the simply stated Bernoulli Effect.

The directions of the force arrows, W (straight down), P-bottom and P-top should serve to satisfy students that the net force due to pressure difference serves to suspend the ball and to hold it in the air stream.

In order to further show this, suspend the ball in a vertical, maximum speed air stream again. Using three fingers, push sideways (horizontally) on the ball, displacing it from the center of the stream, but not so far that it falls. Move the ball back and forth several times this way, pointing out that the part of the ball at the edge of the air stream is subjected to higher pressure, so it is forced back toward the center of the air stream. This is the reason the ball remains suspended in the vertical air stream, despite the fact that it experiences some horizontal “jiggling” forces (due to air turbulence) that tend to force it out so it would fall.

Performance Assessment:

Give each student a sheet of 8.5 inch × 11 inch paper. Ask them to hold the sheet by the corners of its shorter edge and to hold the edge tautly and horizontal. Now challenge them to make the paper rise up without moving it or touching it with any object.

You probably will see a student blow across the top of his/her sheet, causing it to rise up. When most students have caught on, ask them to write an explanation on the paper, using the simply stated Bernoulli Effect.

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Surface Tension

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Objective(s):

This activity is written for third to eighth grades or as an introduction to the topic. Depending on how you choose to supplement the information this miniteach may be used for higher or lower levels.
Students will become familiar with surface tension.
Students will determine if soap and heat will affect surface tension.

Materials Needed:

For all to use: One hot plate and a large beaker

For each group you intend to have:
Four small clear plastic cups
Water
Two boxes of gem clips (paper clips)
Dishwashing liquid (just a few drops)
Paper towels
Black pen for labeling

Strategy:

1. Label four cups with A, B, C, and D.
2. Place a beaker of water on the hot plate and heat it until it reaches a boil (be very careful it will be hot).
3. While waiting for the water to boil, fill Cup A to the brim with tap water. Do the same for Cup B. Be sure the water in each cup is exactly to the rim of the cup without spilling over the side.
4. Drop one gem clip at a time carefully into Cup A until you see the water begin to seep over the side of the cup. Count the number of gem clips it takes to cause this to occur. Record this number in a chart and describe the dome of water building on top of the cup.
5. Now add five drops of dishwashing detergent to Cup B and allow about a minute for it to disperse in the water. Repeat the process you used with Cup A. Count the number of gem clips required to cause the water to seep over the side of the cup. Record this in a chart and describe the dome of water building on top of the cup.
6. Fill Cups C and D to the top with the water you have been heating on the hot plate. Be VERY careful not to burn yourself with the hot water or the hot container. Make sure you get the water level to the rim as you did with Cups A and B.
7. Add five drops of dishwashing detergent to Cup D and allow about a minute

for it to disperse in the water.

8. Add gem clips to Cup C until water overflows. Describe the dome. Record this information. Repeat this process for Cup D and record your results in the chart.

Performance Assessment:

Students will demonstrate the ability to work scientifically and accurately in the lab.
Students will answer questions as to why the water looked dome-like and took so long to overflow.
Students will make a hypothesis as to why and how the different conditions in the water affected the surface tension.
Students should analyze error in technique that may have affected the results.

Conclusions:

Students explore the possibilities of surface tension. They will see how detergent and heat lower surface tension. Higher level students may explore bonds and polarity affecting surface tension.

References:

Walker, Pam and Elaine Wood.
"Surface Tension." **Hands on General Science Activities with Real-Life Application.** The Center for Applied Research in Education.

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Mathematics/Physics

Compared to What? – Comparing the Density of Different Liquids

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Objective(s):

Demonstrate that different liquids have different densities. Initial activity can be conducted with primary level children. Calculations for finding the densities are appropriate for sixth grade or above.

Materials Needed:

water, liquid dish washing detergent (Palmolive), cooking oil (Wesson), corn syrup, food coloring, small spatulas or scrapers, four tablespoons, digital scale, four graduated beakers, (each group will need 5 clear plastic cups)

Strategy:

Divide the class into four groups.

Teacher preparation: Place each of the four liquids in containers. Label the containers; A (cooking oil), B (water), C (dish washing liquid), D (corn syrup). Pour a few drops of red food coloring into the container holding the water. Place one tablespoon with each of the four liquids. Give each student group five clear plastic cups.

Student Activity: A representative from each group will put 3 tablespoons of cooking oil in a cup, 3 tablespoons of liquid detergent in another cup, 6 tablespoons of water in a third cup. Pour the contents of cup A (oil) into a clear empty cup. Pour ½ of the contents of cup B (water) into the cup with the oil. Observe and record the result. Pour the remaining contents of cup B (water) into an empty cup. Pour the contents of cup C (dish washing liquid) into the cup with the water. Observe and record the results. Make a prediction. If the contents of the first cup are poured into the second cup, how will the liquids layer themselves. Record that prediction. Now pour the contents of the first cup into the second cup. Check the accuracy of your prediction and record the results. **Do not use the contents of cup D yet.**

Teacher preparation: Distribute one liquid to each of the four groups. (The fourth group will get liquid D now.) Instruct the groups to follow the directions listed immediately below.

Student activity: 1^{st} student weighs the empty graduated beaker and records its weight. 2^{nd} student puts 50 ml. of the liquid into the beaker. 3^{rd} student weighs and records the beaker and its contents. 4^{th} student subtracts the weight of the empty container from the weight of the container holding the liquid to determine the weight (mass) of the liquid. 5^{th} student calculates the density by dividing the weight (mass) by the volume (50ml.)

Performance Assessment:

Primary Level:

Ask

- Which liquid is at the bottom? Why is that so?
- Which liquid is in the middle? Why is that so?
- Which liquid is at the top? Why is that so?

Intermediate/Upper:

After each group calculates the density of its liquid, those calculations should be arranged from lightest to heaviest on the chalkboard. If the students have performed the measurements and the calculations correctly the numerical arrangement of the densities should mirror the density layers they created in their cups. Ask the students to predict where liquid D should layer itself based on their calculations. Groups who have the corn oil, the water, and the dishwashing liquid should place three tablespoons of corn syrup into their density cups. Liquid D, the corn syrup, should sink to the bottom since its density is the heaviest of the four.

References:

A Quantitative Approach to Science. Chicago Board of Education, 1985.

Whelmers. Steven L. Jacobs. Science Demonstrations That Spark Your Imagination, 1994.

Buoyancy: What will float and what will sink

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Objectives:

This lesson is aimed at the intermediate grade levels (4-6). The students will be able to write and verbally explain why a particular object/item will sink or float. They will also be able to illustrate and/or demonstrate this process. This assignment will either introduce graphing or enhance a students graphing skills, as well as their critical thinking skills.

Materials Needed:

1 Large Clear Container - filled with water
2 Balloons of the same color (one filled with water and one filled with air but close to the same size)
1 Regular Coke
1 Diet Coke
2 Empty 16oz clear water bottles. (one filled with a much heavier substance than the other. Ex: Flour and Salt; air and water; Salt and sugar)
Fruit: two of each of the following: pear, apple, orange, nectarine, banana, lime, potato, plum, tomato, lemon, etc.
Enough copies of a graphing chart of which fruit will float and which will sink
1 Roll of aluminum foil
100 pennies
1 empty but clear dish washing detergent bottle with cap
2 glass droplets

Strategy:

I have a container of water and two balloons of the same color. (One is filled with water and the other with air. DO NOT INFORM THE STUDENTS OF THE BALLOONS CONTENT). At this time, I will show the students the two balloons and ask them as I place each one in the water what do they think will happen? (Placing the two balloons in the container, I now wait and listen to the students observation). POSSIBLE ANSWERS: One sunk because of its weight, one balloon was bigger than the other, one is filled with water and one with air.

Then, I will continue with the two pop cans. I will show the class, two 12oz pops, one being diet and the other regular. I will ask them, what do they think will happen as I place both cans into the container of water? (At this time I'm listening to the students responses.) Then I place the two cans of pop into the container of water, and one floats and the other doesn't. I ask why? (Listen to their responses.) Then, explain why what happened, happened. Diet coke contains nutra-sweet and regular coke contains corn syrup. Corn syrup is more dense than the nutra-sweet that is in the diet coke; therefore, the diet coke was able to float more than the regular coke. Cheap pop may float, not enough corn syrup.

Next, I will hold up two 16oz clear water bottles filled with a white content (one with baking soda and the other salt.) Once again, I will ask the students what they think will happen when I place them in the container of water? POSSIBLE ANSWERS: one will sink, the other will float. They both will sink or float. Well, after placing both bottles in the water, the students received a surprise. They both sunk! Why? I listen to the observations and let them discuss what they think happened. (That is why under the materials I listed several contents. Water and air would have been a good example because one would have floated and the other would not have. However, I wanted the kids to see something different.)

Moving right a long, I introduce the class to the different kinds of fruit I have available. I ask that they all come up with their chart and pencil to make a prediction on what fruit will sink and what fruit will float. Then, have them try each fruit in the water and see what happens. This way the children will have a visual graph of what floats and what sinks. (The teacher must do the experiment himself/herself to find out these results. Smile! Have fun.) Afterwards, the students are free to enjoy a piece of fruit. Now, the floor is open for discussion as to what floated and what didn't and why.

All the students will come back up and make a boat or a floating object, one out of foil and one out of Play-Doh. Then, they will place their floating device in the container of water to make sure it floats. If it floats, they will see how many pennies it can hold before sinking. They will write down their results and sit down and as a group they can talk about their finding.

Finally, I will demonstrate buoyancy using the clear dish detergent bottle and the two glass droplets. Filling the bottle with water and filling one droplet with water and the other half filled with water. Then dropping both droplets in the bottle, closing it tight. One droplet will sink to the bottom, while the other will float to the top. Place your hands just below the neck and squeeze with you thumb and observe what happens. Then repeat the process using your three fingers.

Performance Assessment:

I would expect each student to participate in all exercises. They should all have an idea about why something happened. I would expect that all the students should have a clear understanding of buoyancy, considering the various experiences. Assessing the students should not be stressful. They should be able to identify this concept when they come across it again.

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Air Pressure

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Objective:

The main objective of the mini-teach is to demonstrate an understanding of how air pressure works. Students will be able to identify, construct, and define the concept of air pressure by working in groups after experimenting with various activities on air pressure. Students will also have a working knowledge of the different terminology used when describing the process of air pressure.

Activity #1: Water Fountain

Materials:

2 jars (one with the lid), 4 straws, small bucket, water, tape

Strategy:

Make two holes in the jar lid, one hole in the middle of the lid and the other near the edge. Place one straw in the middle hole and secure both ends of the hole with clay. Now tape the three straws together and place one end inside the second hole of the jar lid about an inch. Secure both ends of this hole with clay. Fill jar #1 without the lid about three-fourths of the way with water. Now fill jar #2 with the lid about 2 inches high with water and then close the lid. Take jar #2 with the lid and turn it over so that the one straw in the middle hole is half-way in jar #1 and half-way in jar #2. While the other straws which are connected are hanging over the edge into a small bucket. Now observe what happens in jar #1 and jar #2.

Results:

As the water from the closed lid jar #2 pours down into the small bucket through the connected straws, the air pressure inside the jar become less as the air spreads out to take up space left by the water. The air outside in jar #1 is at a greater pressure than the air inside, thus forcing the water up the straw and making a fountain.

Activity #2: The Magic Glass

Materials:

Jar, 4"x6" index card, water

Strategy:

Fill the jar to the top with water and wet the rim slightly. Lay the card on the top of the jar. Hold the card firmly in place and turn the jar over.

Now take away your hand and see what happens.

Results:

The water should stay in the glass, showing that air pressure is exerted on the card from the top, the side, and the bottom as Pascal's law states.

Activity #3: Candle In Glass

Materials:

Shallow dish or pan, candle, matches, tall glass or flask, food coloring

Strategy:

Light a candle and stand it upright in the middle of a pan and secure it with melted candle drippings. Fill the pan half full with water. Then add a drop of food coloring to the water to make it more noticeable from the back of the room. While the candle is still burning, place a narrow glass or flask over the candle. Carefully observe the base of the container, the water level in the container, and the flame. Record your observations.

Results:

The candle will burn for a time but will eventually go out and you will see that the water rises up into the jar. You will find out that the water will rise about one-fifth of the way up the jar. Water rises in the container due to an imbalance in pressure. As the gas inside the container heats and expands causing bubbling around the base. The oxygen inside diminishes, the flame gets cooler, and so does the air resulting in a pressure drop. Water starts to move into the container. When the candle is extinguished, the temperature in the flask drops, causing a further reduction in pressure and a further rise in the water level.

Activity #4: The Power of Air

Materials:

Ruler, 2 sheets of notebook paper, 2 sheets of newspaper

Strategy:

Lay the ruler on the table so about one-third of it lies over the edge. Place two sheets of notebook paper on the ruler and press against the table until the paper is flat as possible. Now hit the overhanging portion of the ruler with your hand and try to make the paper fly into the air. Repeat this procedure using two sheets of unfolded newspaper and record your results.

Results:

The ruler should snap when placed under the newspaper, but not when placed under the notebook paper. The notebook paper is small enough that the ruler can lift it without breaking. While the newspaper has a much greater surface area than the notebook paper. The air presses down on the sheet of newspaper, there is a lot of air pushing down on it and this is enough to stop the paper and ruler from moving.

Performance Assessments:

Through an oral evaluation and teacher observations each student will have to describe the procedure of each activity and the results of each experiment. Explaining what happens when their is an indifference in air pressure and what caused it.

Conclusion:

After experimenting with each activity, each student should have an excellent idea of how air pressure works. While having a working knowledge of some of the key terms associated with air pressure such as: high air pressure, difference in pressure, and low air pressure.

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Buoyant Force

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Objectives:

This activity was designed for grades 4th thru 8th. Students will be able to construct a graph that illustrates Archimedes' principle of buoyant force. Students will also be able to understand that the buoyant force on an object is equal to the weight of the fluid it displaces.

Materials Needed:

Students will be in groups of 3-4 individuals. Each group should have the following items:

2 liter bottles (tops cut away)	4ea.
Various objects that sink (pad-lock, stone, metal,etc)	3ea.
Various objects that float (candle, styrofoam, toys, etc.)	3ea.
Objects that sink but, float (fruits, lime, apples, etc.)	3ea.
water balloons	3ea.
1/4" plastic tubing	1ea.
spring scale	1ea.

An overflow container must be constructed from one of the 2 liter bottles. First take a Phillips screw driver and heat the tip over an open flame. Next, melt a hole into the plastic container 2-4 cm from the top of the container. Now, force the 1/4" tubing into the hole and secure a tight fit so as not to allow any water to leak out. A styrofoam cup can be used to catch the water flowing from the overflow container and thru the tubing. Finally, fill the container with water until water starts to flow through the plastic tubing. When the water stops flowing through the tube then you have reached a proper water level to perform the experiments. This water level must be reached before beginning each experiment.

Strategy:

Students will be introduced to the concept of buoyancy by observing the first exercise. Two 2 liter containers filled 3/4 of the way with water. In one container place an object that sinks. In another container place an object that floats. Ask the students to observe the two containers and discuss what they see. One key observation should be the change in the water levels and or the displacement of water. After the observation, inform the students that the buoyant force is equal to the weight of the water displaced, and the following experiment will either prove or disproves the theory. Students should weigh an object on a scale, be sure to put all readings on a data table. Next, place the object into an overflow container. The object will displace water into a container or graduated cylinder. Now, weigh the water in the container. Repeat this step for each object and record all the readings on the data table. The students are now ready to construct a graph that illustrates weight of an object vs weight of water displaced. The graph can be done as a group, individual, or class project. The first graph can be done as a class project, by drawing a graph on the board or using an over head projector. Have each group give their findings, from the data table, plot the findings on the graph. The objects that float should cluster together at one end of the graph and the objects that sink should cluster together at the other end of the graph. The water balloons should give you a forty-five degree angle on your graph to divide your graph in two.

Performance Assessment:

Students will receive a maximum of 40 points for completing the data table. Students will also receive a maximum of 40 points for the graph. A short answer quiz worth 20 points will also be administered. A maximum of 100 points is possible.

```
100 - 90 = A
 89 - 80 = B
 79 - 70 = C
 69 - 50 = D
 49 - 20 = F
 19 -  0 = 0
```

Reference:

"Archimedes' Principle", **Encyclopedia Britanica**, 1991.

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Do You Sink or Float?

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Objectives:

Students in first grade will discover objects that sink or float through observation, classification, gathering data, and interpreting data.

Materials Needed:

A variety of different objects
clay
aluminum
pennies
A variety of different fruit
A variety of different types of balls
5 large clear containers for water
towels
water

Strategy:

Opening Activity:
Place a variety of objects into a clear tank filled with water. Ask the children what they observe after each object is placed in the water. Discuss the words sink and float. Have each child take one object, predict if it will sink or float and place it into the water. Ask the children why did some of these objects sink and some float? After the discussion, the students will break up into five groups to explore the concept of sink or float at learning stations.

Stations:

1. Students will play the game "Sinker or Floater" to acquire a better sense of which materials sink or float. Each child takes a turn by reaching into a bag of objects and stating if that object will sink or float. Next, the student places the object in the water and if their prediction was correct they get a point. The students continue the game until all the objects have been selected.

2. Students will discover which fruits float by placing a variety of fruit into a deep container of water. Next, they will draw pictures, on a given piece of paper, illustrating their findings on which fruit floats or sinks.

3. Students will make a boat using clay. Next, they will predict, on a class graph, how many pennies their boat will hold without sinking. Third, they will put their boat in the water container and place pennies inside the boat. Fourth, they will put their actual number of pennies the boat held without sinking. Last, the students will put their name on their boat and place it aside for a group comparison.

4. Students will repeat the exact steps for station 3 using aluminum foil rather than clay.

5. Students will experiment with a variety of balls (golf ball, tennis ball,

football, soccer ball, etc.) to see if they sink or float. First, they will predict by making a real graph, using the actual balls, showing which balls will sink and which will float. Second, they will test each ball in the water container. Last, they will make their own graph, using crayons and paper, to illustrate what they have discovered.

Performance Assessment:

After the students have completed all stations, discuss observations made at each. The students will be assessed on their participation in the group discussion and their work created at each learning station.

References:

AIMS Spring Into Math and Science K-1

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Bernoulli Effect

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Objective:

This lesson will show the relationship between velocity and pressure of a fluid. The demonstrations should be appropriate for all levels. The explanations may be more suitable for upper level and high school.

Materials Needed:

1. Coat hanger and two strips of paper (about 4 cm X 12 cm)
2. Hair blower and ping-pong ball
3. Ruler and strip of paper (about 2.5 cm x 5 cm)
4. Two aluminum cans connected by a string (about 1 m long)
5. Bits of paper and whee-o (thin flexible tube, similar to vacuum cleaner hose, about 3 cm diameter and 50-75 cm long)
6. Thread spool, straight pin, and index card
7. Funnel and ping-pong
8. Long narrow plastic bag (two newspaper covers taped together work well.)

Procedures:

Explain each of the items and ask for predictions about what will happen in each case. Demonstrate each of the items or have the students go through each procedure and make observations.

1. Cut off the long side of the coathanger and bend the other sides so that they are parallel to each other. Tape the strips of paper to opposite sides so that they hang down parallel to each other. Blow down between the two strips.

2. A hair blower with a straight nozzle works well.
   A paper cup with the bottom cut out stuck on the end of the blower also works. Turn on the blower and place the ping-pong ball in the air stream. Tilt the blower.

3. Tape the paper to the ruler so that it forms an air foil. Place a pencil on a table and place the mid point of the ruler across the pencil. Blow across the top of the paper.

4. Hang the cans so that they are at the same level and about 2 cm apart. Hold a ruler behind the cans and blow between the cans. (This also works with two apples or two balloons.)

5. Hold the bits of paper in one hand. Place one end of the whee-o over the paper and twirl the whee-o.

6. Stick the pin through the index card and then into the hole on one side of the spool. Blow into the other hole of the spool.

7. Place the ping-pong ball in the funnel. (The top part of a plastic bottle makes a good funnel.) Blow up through the small end of the funnel.

8. Challenge someone to blow up the bag with as few breaths as possible. It will take about five breaths. Flatten the bag. Then claim to be able to blow it up with one breath. Hold the bag open and quickly blow into the bag from about 30 cm away.

Observations:

1. The bottom ends of the strips will move closer together.
2. The ball will rise and float in the air stream.
3. The end of the ruler with the air foil will rise.
4. The cans will move closer together.
5. The bits of paper will be sucked up into the whee-o.
6. The card will remain in place.
7. The ball will stay in the funnel.
8. The bag will fill with air.

Explanations:

The higher the velocity of a fluid, the lower the pressure. This is called the Bernoulli Effect. Each of these activities demonstrate the Bernoulli Effect.

1. The velocity of the air is greater between the two strips. Therefore the pressure is lower between the strips. The higher pressure on the sides pushes the strips together.

2. The air in the stream is faster than the air outside the stream. The higher pressure outside the stream keeps the ball in the stream.

3. The air above the air foil is faster than the air below. The higher pressure below pushes the air foil up.

4. The air between the cans is faster than the air on the sides. The higher pressure on the sides pushes the cans together.

5. The air inside the whee-o is faster than the air outside. The higher pressure outside pushes the paper into the whee-o.

6. The air between the spool and card is faster than the air on the opposite side of the card. The higher pressure on the opposite side pushes the card against the spool.

7. The air is faster below the ball and on the sides. The higher pressure above the ball pushes the ball down into the funnel.

8. The air inside the bag is faster than the air outside the bag. The higher pressure outside pushes the air inside.

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Bubbleology Mickey Mouse Style

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Objective:

This two day lesson is designed for an intermediate grade level. After blowing bubbles, students will be able to test the effect of four different shape wands and three geometric figures in a bubble mixture. Students will construct water and soap molecules.

Hypothesis:

Does a bubble always form a sphere?

Materials Needed:

Dawn dishwashing liquid, cups, water, yarn, scissors, construction paper, glue, pipecleaners, string, straws, trays, and a large container.

BUBBLE MAKERS

INDIVIDUAL WANDS

Bend pipecleaner to form a circle, square, heart, and triangle.

RECTANGULAR FRAME

Materials: two standard drinking straws; a piece of cotton string 11/2m long. Procedure: Feed the string through both straws and tie a knot.

TETRAHEDRON

Materials: Three standard drinking straws; three half-size straws; and nine pipecleaners. Procedure: Twist two pipecleaners together to make a pipecleaner that is somewhat longer than a standard drinking straw; repeat twice. Put three long pipe cleaners together and twist them together at the top. Slip three standard drinking straws onto the pipecleaners; bend the pipecleaners at the bottom to form feet. Insert three standard pipecleaners through three half-size straws. Make a triangle with them by twisting their corners together. Twist base and top together at corners.

CUBE

Materials: Six standard drinking straws, each cut in half; and twelve pipe cleaners. Procedure: Put three of the pipecleaners together and twist them tightly at one end. Make four complete sets. Slip half-straws onto the pipe cleaner; bend the pipe cleaner to form feet. Make each set look like the capital letter T. Use two sets to form a square with two extended sides. Repeat the procedure with the other two sets. Make one square bottom of the cube by twisting up the extended straws; make the other square the top by twisting the down the extended straws. Fit the top to the bottom, twisting all corners.

Strategy:

Cooperative Learning

1. Each student receives 4 pipe cleaners, a straw, and a cup.
2. Make a circle, square, heart, and triangle with a pipecleaner.
3. Cover the bottom of the cup with Dawn dishwashing liquid.

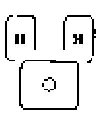
4. Fill the cup with a 1/2 cup of water.
5. Blow bubbles indoors and outdoors.
6. Record results on Bubbleology worksheet.
7. Form three groups.
8. Build a rectangular frame, tetrahedron, and a cube.
9. Record results on Bubbleology worksheet.

Bubbleology Worksheet

WAND **SHAPE**	PREDICT **SHAPE**	INSIDE **SHAPE**	OUTSIDE **SHAPE**	DRAW SHAPE	COMMENTS
CIRCLE					
SQUARE					
HEART					
TRIANGLE					
STRAW					
PIPE CLEANER					
RECTANGULAR FORM					
TETRAHEDRON					
CUBE					

Day two

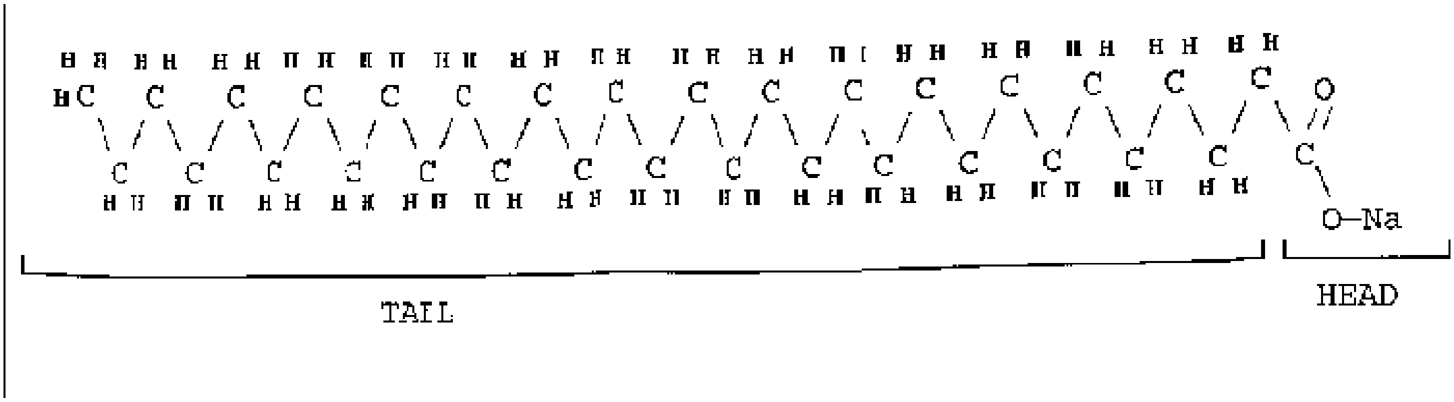
1.Draw and cut out a water molecule that looks like Mickey Mouse.



2. Paste the water molecule on construction paper.

(continued on next page)

3. Draw and cut out a simple soap molecule. (Don't forget to draw circles around the molecules.)



4. Paste the soap molecule on construction paper.
5. Discuss the simularities and differences between water and soap molecules.

Performance Assessment:

Students are evaluated by completing the bubbleology worksheet and constructing water and soap molecules . This assignment is graded as a pass or fail lab in class assignment.

Conclusion:

Regardless of the shape of the wand, bubbles always form spheres.

Reference:

Science and Children, May 1986
Science Scope, October 1988
AIMS Education Foundation, 1988

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Pressure in Fluids

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Objectives:

We shall study the properties of fluids under a variety of circumstances to understand the role or pressure in their behavior, and to relate to everyday circumstances.

Materials Needed:

Several two liter "pop bottles" and assorted plastic bottles, several "push pins" for making holes, a medicine dropper for the cartesian diver, a large clear funnel with a stand for holding it in place, several plastic straws and a supply of strong plastic tape or **Duck Tape**, and at least one "middle range" water pistol, a "battery operated" model being preferable.

Strategy:

The first phase is a demonstration of the flow of water out of holes punched with push pins **and some enlarged with nails** in plastic bottles of various shapes and sizes. Let the students report their observations, and write them on the board. Be sure to record every correct observation, whether it is directly relevant for the points you intend to make. Here is a **non-inclusive** list of observations that might be made.

1. If the hole is punched straight into the bottle, the water initially moves horizontally, and gradually drops as it gets further away from the vessel.
2. As the water drains from one of the bottles and the level drops, the water comes out with lesser speed, and falls on an arc that does not extend as far.
3. The stream of water initially gets **smaller** as it leaves the hole, and it will break into droplets if it falls far enough. **Try this with a hole punched in the bottom of the bottle**.
4. If the cap is put back on the bottle the flow slows and eventually stops. If you blow hard into the bottle the rate of flow is increased.
5. With two holes of the same size, the one that is deeper in relation to the "water level" in the bottle will have a greater exit speed.
6. The size of the hole has relatively little effect on the speed of water that exits, although, a bigger stream of water flows out of the larger hole.

Next go outside with the water pistol and shoot it from shoulder level. Have the students divide into groups of three or four, with each group estimating its maximum distance of travel **in meters** by stepping or pacing the distance. Be sure to take along an extra supply of water for reloading the pistol. Go back inside, and record the various answers. You should measure the distance in advance, so that the various answers obtained can be compared with the standard. For the **Drencher Advantage™** power pistol, a range of about 9 meters was obtained.

Fill a two liter pop bottle with water. Take a medicine dropper and fill it partially, so that the dropper just sinks in the water inside the bottle. It will take some experimentation to find the right amount of water in the dropper. Then put the lid tightly onto the bottle. Squeeze the sides of the bottle. Notice that, as the water pressure inside the bottle is increased thereby, the air in the dropper is compressed, and the dropper falls. You might enjoy repeating the experiment with an oval-shaped bottle. The device is called a **Cartesian Diver**.

Fill a bottle completely with water, and insert a plastic straw. Use tape to hold the straw a few millimeters above the top of the bottle and to seal the bottle. Blow gently over the straw, either directly or by means of another straw. If possible, use an air pump to force air over the top of the straw. You will notice that water comes out of the bottle. The water is forced up and out of the straw because of the **Bernoulli Principle**. This mechanism is used **aerosol cans**, in that a liquid is ejected from the reservoir by passing a gas over a tube at high speed.

Many many people believe that the water in a flushing toilet or a draining bathtub will circulate in one sense in the Northern Hemisphere, and in another sense in the Southern Hemisphere, because of the **Coriolis Force, which is responsible for clockwise circulation around high pressure regions and counter-clockwise circulation around low pressure regions in the atmosphere.** Actually, it is difficult to build a toilet or tub that does not have some directional bias and it is simpler to study the effect in a large clear funnel. Fill the funnel with water and **add dye to enhance visibility** while holding your finger on the bottom of the funnel. You will have to pour the water into the funnel symmetrically and wait for several minutes to avoid any residual circulation of the water. Do you see the effect of the Coriolis Force?

Performance Assessment:

Laboratory Exercise:

Punch a hole on the side of a 2 liter pop bottle near the bottom, and fill it with water. Place the bottle on the edge of a table. When the level of water is at a depth **d** above the hole, determine the horizontal distance **s** that the fluid stream lies when it has fallen to a fixed distance of, say, **20 cm** below the hole. Make measurements of **h** for various values of **d**, and make a graph of **d versus h**. Does the graph correspond to a straight line?

Written question:

How does a water pistol work?

Satisfactory Answer:

A pump [mechanical or electrical] builds up pressure inside the vessel partially filled with water, and water is forced out of the hole in the barrel. The operation is exactly the same as that of blowing into the partially filled bottle with a hole in it below the water level.

Conclusions:

The consequences of **Pascal's Principle** [the pressure in a liquid increases with depth and its extension the **Bernoulli Principle** [lower pressure corresponds to higher speed along the path of flow of a fluid] have been explored, and their implications in everyday experiences are examined.

Multi-cultural Components:

A story by **Hans Christian Anderson** describes the little Dutch boy who put his finger into the dike to block whole North Sea. The boy is often depicted wearing wooden shoes.

> **Q**: Why are wooden shoes popular in Holland and other lowland countries?
> **A**: They are very effective in walking through mud, and it is quite easy to remove the mud afterward without damaging the shoes.

You may know that there is a difference in ocean levels of the locks at the two ends of the **Panama Canal**. Part of this difference occurs because the **Pacific Ocean** is more salty and therefore more dense, so that its level should be lower. Incidentally, the locks on the Atlantic side of the canal are further **West** than those on its Pacific side!

References:

Jearl Walker
The Flying Circus of Physics With Answers
Wiley 1975
ISBN 0 - 471 - 02984 - X

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Surface Tension

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Objective:

To understand the concept "Surface Tension", through several experiments. Designed for students grades 5 through 8.

Materials Needed:

Overhead projector (teacher demonstration)
2 glasses of equal size and depth
a bucket
water
pennies 60 per group or person
bowls 2 per group or person
a box of toothpicks
liquid soap or detergent
a box of cube sugar
clear cups 1 per group or person
bubble solution
bubble wands or other bubble instruments

Strategy:

Students will be asked to brainstorm what surface and tension mean. Also, discuss where they have heard the words before. All comments will be written on the black board. After all demonstrations students will comeback to these comments and form a definition(s).

Experiment 1: Teacher will fill two glasses underwater. Then take them out of the water, holding them rim-to-rim so no water escapes. Stand the glasses on a flat surface so that one rests upside down on top of the other. Teacher will slide one penny between the two rims. When the coin is in place, water molecules will pull together between the rims and stop the water overflowing.

Question: Why did the water stop dripping, even though there is still an opening?

Answer: The molecules are pulling and stretching to form a skin to the water. Thus no water can get out, unless the surface tension is broken.

Experiment 2: Teacher will use the overhead projector to demonstrate. Arrange toothpicks in a circle in a bowl of water. Place a cube of sugar in the center of the circle (place bowl on top of overhead projector). Take another bowl, arrange the toothpicks in a circle again. This time place aa piece of soap or liquid detergent in the center (place the bowl on top of projector). Students should observe and verbally respond, the toothpicks went toward the sugar and they went away from the detergent.

Question: Why did the sugar draw the toothpicks and why did the detergent repel the toothpicks?

Answer: The sugar sucks up water, creating a current that carries the toothpicks with it toward the center. The soap, on the other hand, gives off an oily film that spreads outward. It weakens the surface tension, and the film carries the toothpicks away with it.

Experiment 3: A clear cup with a drop of food coloring, should be placed on top a white piece of paper. Near by should be a bag of at least 60 pennies. (Teacher should set these items up, as stations, in the designated area before children begin) Explanation: Tell the students that they are going to fill their cups up to the brim with water. They will then have someone slide pennies into the color cup of water, until the color water drips on the paper. Tell students not to throw the pennies, they want a drip not a splash. One student in the group should be designated to count the pennies going into the water. They are to this until there is a drip on the paper.

Question: Why does it take so long for the water to drip?

Answer: Surface tension builds around the cup, until it is broken with a penny.

Performance Assessment:

Students will be asked to explain surface tension verbally. They will also be instructed to write one or two sentences defining surface tension.

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Displacement of Fluids

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Objectives:

This activity was designed for grades 4th thru 8th. Students will acquire a working definition of the word "displacement". Students will also understand that the volume (size) of an object placed in water affects the amount of water that is displaced.

Materials Needed:

Students will be in groups of 3-4 individuals. Each group should have the following items:

2 liter bottles (tops cut away)	3ea.
300 gram weight	1ea.
800 gram weight	1ea.
1200 gram weight	1ea.
1 liter graduated cylinder	1ea.
balancing scale	1ea.
styrofoam cup	1ea.
1/4" plastic tubing (ink pen shell)	1ea.

2 objects same weight (500-1200grams) but different volumes
2 objects same volume but different weights (1 plastic block & 1 styrofoam block)

The 2 liter bottles are converted into overflow containers by taking a Phillips screw driver and heating the tip and using the tip to melt a hole into the container. The hole should be 3cm - 4cm from the top of the container. Next, place the 1/4" tubing into the hole, making sure to get a tight fit. The tubing allows for all the water from the container to flow into the graduated cylinder. * Note the water level should be at the point that water flows thru the tubing then stops. This level should be reached before performing exercises 2 thru 4.

Strategy:

Students will be introduced to the concept of displacement by observing the following exercise. Take two 2 liter containers filled 3/4 of the way with water. A 200 gram weight is placed in one of the containers of water and a 1,000 gram weight placed into the other container. Students should notice that the water levels have increased. Students should also notice that the container with the 1,000 gram weight has the higher water level. Students are then informed that, in each case, the change in water levels is a measure of **displacement**. Displacement is the amount of change in fluid volume from the initial point (beginning water level) to an ending point. Students are then asked to construct a definition of the word displacement based on their observations. Students are then asked to theorize as to what led to the different levels of displacement. Most students tend to theorize that the heavier objects' weight leads to a higher water level. Students are now ready to perform the following experiments to test their theories. Have students form groups of 3 or 4 individuals, so that each group will conduct the following experiments.

Experiment 1:

Place the various weights (300, 800, and 1200 grams) into different identical containers and notice the change in water levels of the three containers. Once again, students should notice that the greater the weight in the container the higher the level of displacement. This observation may lead to the conclusion that the weight of an object affects the amount of water that a object displaces.

Experiment 2:

On a balance scale have students weigh the two objects of the same weight but different sizes. Next, place each object into an overflow container and measure the amount of water displaced. Any object that floats should be held below the water level, until the (displaced) water empties into the graduated cylinder. Students should notice that the object with more volume (greater size) displaces more water. Students conclude that it is an objects' size that determines the amount of water displaced. To prove the findings of experiment 2, perform experiment 3.

Experiment 3:

Place the two objects of similar volumes and different weights into the overflow containers. Students should notice that both objects displace similar amounts of water, which would substantiate the findings of experiment 2.

Experiment 4:

Now place the 300 gram weight into the over flow cylinder and record the amount of water displaced. Next, hold an inverted styrofoam cup submerged under water and record the amount of water displaced. Once again, students should notice that the cup displaces more water than its weight, further illustrating that it is the volume of an object that determines the amount of water that the object displaces.

Performance Assessment:

Students will receive a maximum of 20 points for each experiment completed. A two question essay (20 points) will also be administered. A maximum of 100 points is possible.

100-90	= A
89-80	= B
79-70	= C
69-50	= D
49-20	= F
19-0	= 0

References:

"Archimedes' Principle", **Encyclopedia Britannica**, 1991.

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Sinking And Floating

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Objectives:

The mini-teach is adapted to grade levels 3-6 and special education.
The main objective of the mini-teach is to explain the Archimedes' Principle, which states that any body completely or partially submerged in a fluid at rest is acted upon by an upward force. The size of the force is equal to the weight of the water displaced. Using this principle, students would be able to tell why some things sink and float.

Materials Needed:

Materials per students

A. Deep-water diver
1. plastic pen top
2. 16oz. of water
3. modeling clay
4. 16oz. clear plastic bottle

B. A Cartesian Diver
1. 16oz. plastic bottle
2. 1 drinking straw
3. 1 bottle top full of modeling clay
4. 16oz. of water

C. Pushing Water with Different Coins
1. 1 small glass
2. tap water
3. several types of coins
4. 1 marker

D. Floating Boat
1. 20 paper clips
2. aluminum foil
3. ruler
4. bucket of water

Strategy:

A. Deep-water diver
1. Stick a small piece of clay onto the pen top. This is the diver.
2. Put the diver into a glass of water. Remove or add modeling clay until the diver floats upright.
3. Completely fill the bottle with water. Put the diver in and screw the top on tightly.
4. Squeeze the bottle and the diver will float up and down.

B. A Cartesian Diver
1. Fill a plastic bottle with water right to the top.
2. Make a diver from a straw, paperclip and clay. Cut the straw 2 inches long, open up a paperclip, take the straw and put it on each end of the paperclip, apply clay round the end of the paperclip.
3. Test that it floats in a glass of water. Add clay until it only just floats.
4. Once the diver is just floating, put it in the bottle of water.
5. Screw the top on the bottle.
6. Squeeze the bottle gently. The diver should sink. Stop squeezing the bottle and it should rise. A diver like this is called a Cartesian diver.

C. Pushing Water with Different Coins
1. Fill the glass with water so that water is about 1cm from the top.
2. Draw a line on the glass at the top of the water.
3. Slowly drop one penny at a time into the glass. Keep adding pennies until the water spills over the edge.
4. Pour out the water and count how many pennies you used.
5. Fill the glass again to the same line.
6. Slowly drop nickels or dimes or quarters into the glass until the water spills over.
7. Pour out the water and count the coins.

D. Floating Boat
1. Cut 2 - 30cm squares from the aluminum foil.
2. Wrap one of the metal squares around 10 paper clips and squeeze the foil into a tight ball.
3. Fold the four edges of the second aluminum square up to make a small square pan.
4. Place 10 paperclips in the metal pan.
5. Set the metal pan on the water's surface in the bucket.
6. Place the metal ball on the water's surface.

Performance Assessment:

The students will be able to answer the following question using Archimedes' Principle:
1. Why do some objects sink?
2. Why do some objects float?
3. What happens when light objects are placed in water?
4. What happens when heavy objects are placed in water?

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The Unmixables: Investigating Immiscible Liquids

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Objectives:

Upon completion of this lab activity, the student will
(1) Develop an understanding of some properties of liquids.
(2) Develop skills in hypothesizing.
(3) Discover the immiscible properties of different milks.
(4) Discover that some liquids form an emulsion.

Materials:

For each group of four students:
Eyedroppers, food coloring, pie pans, and 1/2 pint cartons of half and half, 2% milk, and whipping cream, and Dawn(r) dish soap (the green concoction) and a 1/2 pint container of water. Nine empty bottles. Instruction sheet and an observation sheet.

Teaching Strategies:

This activity can be done in any format, before beginning the project I would give some background information, such as: some liquids are immiscible: that is, they will not mix completely and permanently with another liquid. Oil and water are two such liquids.

In preparation, students are told to determine the roles of each person in the group. If there are more roles and responsibilities than people in the groups, some may have more than one assignment.

Equipment/material Gatherer:

(gets one pan of milk and one pan of water, one towel, one box of food coloring, and one bottle of green concoction.)

Experimenter

(drops food coloring and the green concoction into the water and milk as consistently as possible; follows suggestions given on this instruction page and those of the observers and notetakers.)

Observer

(verbally notes what occurs accurately.)

Recorder

(jots down all observations and questions as accurately a possible.)

The experiment:

Preliminary procedures: 1. Put the bowls with water and milk next to each other; let the liquids settle to stillness. 2. Help the recorder, the one who takes notes, before beginning the experiment.

The Experiment, part 1: Adding the food coloring

3. Conduct the first part of the experiment by dropping food coloring in

each bowl, trying to be as consistent as possible. Enjoy and try a variety of "drops"!

4. Complete "The Experiment, part 1: Adding the food coloring" by recording what happens.

5. Complete the observation sheet by generating and recording questions that come to your mind during this part of the experiment.

The Experiment, part 2: Adding the Green Concoction

1. Conduct the second part of the experiment by adding one drop of Green Concoction to the largest food coloring and water "blobs".
2. Complete observation sheet.
3. Add more drops of Green Concoction and watch what happens!
4. Recorder generates and records questions that come to mind during this part of the experiment.

The Experiment, Conclusion

Complete all information by recording what you've learned about the experiment.

Performance Assessment:

We already know that milk contains drops of fat which do not mix with water soluble food coloring. We also know that whenever the dishwashing liquid touches the milk a change occurs. Given this information, what would you do if a oil rig breaks down and spills all of it crude oil into Lake Michigan?

Rubric:

End of Unit Assessment
2 points = Answer with Example and Explanation.
1 point = Answer with Example.
0 points = No Answer.

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Surface Tension

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Objective:

Students will observe forces between the water molecules which form Surface Tension.

Materials:

The following materials are for a class:

1. overhead
2. beaker
3. straight pins
4. water
5. wire (24 cm. long to make a cradle for straight pin)
6. medicine-cups (to hold 1 part Joy)
7. water soluable pens
8. liquid detergent (Joy) & Glycerin
9. square wire frame (use the same wire from cradle)

Strategies:

Surface Tension

a. Fill the beaker with water, (each student has his own beaker and straight pin).

b. Take the straight pin and show that it is not possible to float a straight pin on the water when it is dropped vertically into the water.

c. Fish straight pin out of the water and dry it off or use another needle.

d. Now hold the needle horizontally as close as possible to the surface of the water (without touching the water) and drop it.

Questions

1. Why is it not possible to float the needle on the water when it is dropped vertically?
2. Why is it not possible to float the needle on the water when it is dropped horizontally?
3. What happened?
4. Why did it happen?

e. The teacher will say, "I predict the straight pin will sit on top of the water if placed right."

f. Give students a piece of wire, demonstrate how to make a "wire cradle" for the straight pin.

g. Put the straight pin on the cradle lift it to the surface of the water, remove the cradle without pulling straight pin beneath the surface.

Question

1. What property of the water keeps the straight pin afloat?

EXPLANATION:

When the needle is dropped vertically into the water, it pierces the water surface. The surface tension at that very small area of the straight pin is not large enough to hold the needle afloat. But when the needle is dropped horizontally, a much larger area of the water surface is involved. When the cradle serves to balance the straight pin on the water surface the forces between the water molecules under and around the straight pin are large enough to hold the needle afloat.

II. At this point include a brief talk about molecules. Use a transparency and overhead to illustrate the forces at work between the molecules.

III. The Circle Inside The Frame

a. Make a soap solution by mixing the following liquids: 1 part Joy, 21/2 parts glycerin, and 3 parts water.
b. Place this soap solution in the shallow container, make a soap film by dipping the wire frame in the solution and taking it slowly out.
c. Make a small loop of thread (diam. 3-4cm), wet it in the soap solution and lay it carefully in the soap film.
d. Once the thread loop lies in the soap film, pierce the center of the loop with a dry object (pencil or dry finger).
e. Slant the wire frame, wiggle it, and observe the perfect thread circle move and travel throughout the whole frame.

Question(s)

1. What made the wrinkley thread turn into a perfect circle?
2. What does this tell us about the forces working on it in the soap film?

EXPLANATION:

This demonstration shows that there is indeed a tension working in the soap film. However, the surface tension of water is much greater than that of soapy water.

Performance Assessment:

The performance assessment that I would use represents COLLABORATIVE LEARNING, teacher and students evaluate an investigation.
i.e. 1. What did we do that helped you most to find an answer?
2. What could we have done better?
3. What new ideas did we discover?
4. What materials and equipment helped us most?
5. How did we use measurements to help find answers?

Scoring Rubric:

1. 5 points: an explanation that is complete
2. 4 points: if student includes a diagram (a)
3. 3 points: the response is generally correct, but the explanation lacks clarity.
4. 2 points: an object identification, more than one.
5. 1 points: the response is incorrect, wrong use of term(s)

Conclusions:

Each project will be judged according to its relationship to the NGUZA SABA principles of Blackness.
e.g. PRINCIPLES

1. Umoja (unity) Does project encompass at least one science area?
2. Kujichagulia (self-determination) Does the project demonstrate an understanding of a need for Afrikan people to develop solutions for their particular needs?
3. Ujima (collective work and responsibility) Is there evidence of shared responsibility for the development and care of the exhibit?
4. Ujamaa (cooperative economics) Were the materials for the project obtained using self-reliant means?
5. Nia (purpose) Is the project based on a hypothesis?
6. Kuumba (creativity) Are students able to discuss project without reciting the written material of the exhibit?
7. Imani (faith) Is there evidence of dedication among the scientists?

References:

William A. Andrews, T. J. Elgin Wolfe & John F. Eix, Physical Science, (Prentice-Hall, Canada,) 1998.
Paul G. Hewitt, Conceptual Physics 6th edition, (Scott, Foresman,) 1989
Earl Zwicker, 1992
Tiek Liem

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Viscosity

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Objective:

Discover what viscosity is and how it relates to our lives.

Materials:

A device that will allow two or more liquids of different viscosity the opportunity to flow at the same time: marbles, wind-up-toy, timer, funnel, eye dropper, toy car, one uncarpeted board, one carpeted board, soap, chop sticks, empty container, small closed containers of different viscosity liquids, large containers of different viscosity liquids, six same size dictionaries, Kyro syrup 100%, Kyro syrup mixed with water 75%, 50%, 25% and water (100%).

Strategy:

1. Briefly discuss the difference between quantitative and qualitative data. Relate the discussion to the following experiments.

2. Discover friction: create two ramps with the books and the boards. Release the toy car on the uncarpeted board first, then the carpeted board. Ask the students why one is slower. Discuss what happens.

3. Discover the results of friction: Have students rub their hands together. Discuss what happens. Rub the chop sticks together and touch them to the area below the nose. Discuss what happens. Rub the chop sticks with soap and then together and touch them to the area below the nose. Discuss the results.

4. Turn the small containers over allowing the liquids to flow. Point out the movement of the air bubble in each liquid. Discuss what happens.

5. Five groups of students: 0% (Water 100%), 25%, 50%, 75%, 100% Kyro Syrup.

6. Students will time how many drops of liquid comes out of a dropper in ten seconds. Discuss the results.

7. Students will drop marbles into the large containers of liquids and time how long it takes the marbles to travel to the bottom. Five marbles should be timed and an average time computed.

8. Data is collected in a table on the board by students. Each group should discuss their results. The total findings should be discussed.

9. Discover how engines work with different viscosities: Pour the liquids into the empty containers. Wind up the toys and put it into the liquids. Discuss the results.

Conclusion:

Through the step by step discussions, students should begin to realize that viscosity is one of the most important properties of lubricating oil. Viscosity is a measurement of resistance to flow or how thick or thin an oil is. Lubricant flow characteristics are relative to temperature. When temperature is increased, viscosity is decreased and vice-versa. Students should understand the motion of molecules in matter before and after heat is applied.

Reference:

Professional Service Industries Inc. TAI/FABER Division Lab.

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Does AIR Really Exist?

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Objective:

[Grades 3-5]

Given a teacher demonstration and various learning stations, the students will learn that air is a real substance which occupies space, exerts pressure, and has weight.

Materials:

The following materials are needed for the teacher demonstration:
2 large soft drink bottles, pencil, balloon, and container with warm water.

The following materials are needed for each station:
1) Piece of paper, balloon, straw, 2 suction-cup plungers, water, 2 8-ounce plastic tumblers marked A and B, and deep bowl filled with water.
2) Balloon, beaker, test tube, water, ink, plastic bag, twist tie, book, clay, funnel, jar, straw, and water.
3) Large clear glass jar, plastic bag, string, meter stick, string, pencil eraser, ring stand, and balloon.
4) Thin board, newspaper, straws, pin, cups, water or juice, ring stand, plastic tubes, picture of sink and house, air vent, and carpenter's tool.

Procedure:

Teacher demonstration: Set up two large soft drink bottles. Place a pencil into one, but leave the other bottle empty. Have the students verify that one bottle is empty. Next attach a small balloon over the top of the empty bottle. Then set the bottle in a warm container of water (the students should not be told this). As the students observe, the balloon slowly fills up. The students will discover that the bottle was not empty!

Stations:

1. Can I really feel air? Can I see air move?

   A. Fan your face with a piece of paper.
   B. Blow up a balloon and open the end slowly.
   C. Blow through a straw and place your hand near the end of the straw.
   D. Moisten the edges of the two plungers. Push the ends of both plungers together and pull them apart.
   E. Look at the glasses marked A and B. Push glass A, mouth first, into the bowl of water. Turn it on its side. Observe. Push glass B to the bottom of the bowl, mouth first. Put the mouth of glass A right above glass B and slowly tip glass B on its side.

2. Does air occupy space?

   A. Blow up a balloon.
   B. Fill a large beaker half full of water. Add two or three drops of ink to the water. Insert a test tube open end down. The water does not enter the test tube because air occupies the space. Tilt the tube so that some air escapes. Water now enters to occupy the space vacated by the air.
   C. Wave about and collect air in a plastic bag. Quickly close the bag and tie the end with a twist tie. Place the bag on a table top and balance a book on top of the bag.
   D. Mold some clay around the neck of a funnel. Press the funnel into the mouth of a jug so that an airtight seal is created. Quickly pour water into the funnel. Observe. Put a straw into your funnel. With your finger over the upper end of the straw, insert the straw into the neck of the funnel. Push the straw down through the funnel filled with water. Remove your finger from the straw. Continue pouring water into the funnel. Observe.

3. Does air have weight?

   A. A wide glass jar is displayed. Push a plastic bag inside the jar hanging over the rim. Wrap the string around twice around the rim, just below the threads, and tie it tightly. Reach inside the jar and pull the plastic upward. Observe.
   B. Use string to suspend a meter stick in the middle. In one end of a 15-cm (6-in) length of string, make a loop to fit over the end of the meter stick. Tie a pencil eraser to the other end of the string. Tie another loop in a 15-cm. (6-in.) string and tie an empty balloon on the other end of the meter stick and balance it by moving the eraser on the other end of the meter stick. Mark where the eraser loop is on the meter stick. Remove the balloon and inflate it. Retie the balloon in the same place.

4. Does air have pressure?

   A. Ask two students to compete in a drink race. See who can drink a small glass of beverage fastest. See to it that one pupil has a normal straw, but give the other student a straw filled with pinholes. Have the students examine the difference.
   B. This event should be performed by the teacher. Obtain a thin board. Lay the board on a table so that one end extends over the edge by 15 to 30 cm. Place sheets of newspaper over the remainder of the stick on the table. Be sure to place extra sheets directly over the stick so that the stick does not cut through the paper when you perform this event. Ask the pupils to predict what will happen when you push slowly on the stick. Are the newspapers heavy enough to break the stick? Hit the stick sharply.
   C. Plumber's Magic: Set up a model of the p-trap with plastic tubing so that you design a model of a sink. Have the students pour water into the "sink" and observe what happens to the water.

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Air Pressure

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Objective:

To get a better understanding of air pressure and how it effects our daily lives.

Material Needed:

The following materials are needed to complete these activities at various stations:

A. Balloons	F. Balloon pump	K. Plastic cups
B. Water	G. Cottonballs	L. Spheres
C. Plastic bottles	H. Medicine dropper	M. Food coloring (optional)
D. Boiled eggs	I. Suction cups	N. Glass bottles
E. Balance (scales)	J. Paper	O. Model of human breathing system

Recommended strategies:

1. Get the class' attention by having them do breathing exercises, inhaling and exhaling two or three times.

2. Next, asked class how this process is related to air pressure? Use model of breathing system for demonstration.

3. Give a review of the basic concept of air pressure, that is, how it can be weighed, takes up space, and where and how it is found.

4. Take out two plastic bottles and ask class, if the bottles contain air? Demonstrate to class that the bottles contain air by sucking or taking most of the air out of one bottle. Ask student to compare the changes in the two bottles.

5. Next, ask students whether they think that the bottle can be brought back to its original shape? Do this by blowing air back into the bottle.

6. Repeat the same activity by using a balloon.

7. Have student to divide into groups of four, go to assigned stations, and try to understand the principles that we have discussed.

8. Student helpers will be assigned to the stations for assistance.

Station 1:

Students will do this activity to test whether air is in something.

Material needed: 8-ounce plastic tumblers; Tissue; Deep bowl filled with water

Procedure:
1. Look at the glass. What is in it?
2. Crumple the tissue and put it in the bottom of the glass.
3. Turn the glass over (be sure the tissue does not fall out) and push it mouth first into a deep bowl of water.
4. Now remove the glass without tipping it.
5. What happens to the tissue?
6. What can you say about this?

Station 2:

Students will demonstrate and learn what air can do to an egg.

Material needed: Hard boiled egg, peeled; Glass milk bottle; Kitchen matches

Procedure:
1. Stick two matches in the pointed end of the egg.
2. Holding the bottle upside down, light the matches and put the egg into the mouth of the bottle, pointed end in first. Hold the egg lightly against the mouth of the bottle-don't push! Keep the bottle upside down.
3. What happened? What can you say about this?

Station 3:

Students will learn how air can be compressed.

Material needed: Clear plastic 16-ounce shampoo bottle filled with water;
Medicine dropper filled with a small amount of water

Procedure:
1. Observe the medicine dropper floating in the bottle.
2. Gently squeeze the bottle.
3. What happened? What can you say about this?

Station 4:

How can air pressure make things stronger?

Material needed: Paper straws; Raw potato

Procedure:
1. Hold a straw near one end and try to stick the other end in a potato. What happened?
2. Place your finger over the top of the straw and stick the other end into the potato (do it fast and hard). What happened?
3. What can you say about this?

Conclusion & Evaluation:

The conclusion of this lesson is that students will be able to understand air pressure, how and when it works, and some of the concepts that can be achieved by using air pressure.

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AIR PRESSURE

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1-312-334 3651

Objective

The purpose of these demonstrations is to aid the student in learning basic principles of air pressure.

Apparatus Needed

Balloon Glass Jar
Water Soap
Pencil

Balloon In Jar

Inflate the balloon so that it is slightly larger than the mouth of the jar. Try to force the balloon into the jar; it is difficult, if not impossible. Then slide the pencil down beside the balloon and the balloon may be pushed into the jar. The balloon seals the opening of the jar so that air cannot escape around it, and as it is pushed, it tends to compress the air in the jar slightly. It cannot be easily pushed against the air pressure.

Apparatus Needed

Plastic Glass
Hot Water
Smooth Surface

Gliding Glass

Rinse the glass with hot water. Leave a little water in it, and invert the glass onto the smooth surface. The glass will "skitter" around as if on ice, with almost no friction. As the water is poured out of the glass it is replaced by room air. Heat stored in the glass and water, heats the air somewhat; it expands and the pressure lifts the glass a tiny distance from the surface of the table. The glass floats on a film of water and a cushion of air. This is the same principle used by the surface-effect vehicles or "hovercraft."

Apparatus Needed

Erratic Ball

Table Tennis Ball
Thread
Scotch Tape
Soda Straw With Flex

Attach the ball to the end of the string with a tiny piece of tape. Suspend the ball by the string. Blow upward against the ball through the straw. Blow harder, then slowly, and reverse. Blow gently up against the ball, just off center, and the ball will try to "outflank" the air jet by going around it to where it can hang vertically. The ball's motion will be quite erratic. Blow harder and the ball will go into the center of the air stream and tend to remain there. Moving air exerts less pressure than still air, so the ball tends to remain so that the pull of the moving air around it is nearly equal on all sides.

Apparatus Needed

Crushed Jug

Gallon Size Plastic Jug
with screw on lid
Boiling Water

Put boiling water into the jug and shake it with the lid closed, but loose. When steam and water stops coming out, screw the lid on tight. The jug will begin to collapse. The action can be speeded up by using cold water on the jug. As the steam in the air condenses, the pressure in the jug diminishes. Atmospheric pressure crushes it.

Apparatus Needed

The Hovercraft

An Old Long Playing Record
A Wooden Spool
A Candle   A Large Balloon
Smooth Surface

Fix one end of the wooden spool so that the balloon can be slipped over it. Attach the other end of the spool to the center of the record with candle wax or glue. The holes in the spool and record should match. Inflate the balloon, slip its mouth over the spool and place the record on a smooth surface. Release the balloon and the record will glide over the smooth surface with little friction. When the record rests on the surface it tends to remain there because of the friction created when the surfaces move against each other. The air stream from the balloon puts a thin layer of air between the surfaces, eliminating most of the friction.

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The Pressure Of A Liquid

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Objectives

1. Students will see what happens when the pressure of a liquid is not the same on all sides of a submerged object.
2. Students will find out how the pressures of a liquid (water) works.

Equipment and Materials

Part 1	Part 2
empty milk carton	hollow tubes open on both sides (small orange juice can)
a pen or pencil	bowl or basin
a piece of tape the length of carton	metal jar lid
two liter plastic bottle (put hole in bottom of bottle)	water
2 cans (one large, one small)	drinking glass
put hole in each can 2 cm from bottom, fill each can 5cm high	fish tank
drinking glass	

Recommended Strategies

Begin lesson by using phenomenological approach in demonstrating how water pressure works. Using an empty milk carton, a pen or pencil, and a piece of adhesive tape. The length of the carton will help show how water pressure works. Use the pencil to punch three holes, one above the other, on one side of the carton. Make the top hole at least 3cm (1 1/4 inches) from the top of the carton. Cover the holes with the adhesive tape. Fill the carton with water. Put the carton in the sink or bathtub. Strip off the tape quickly. Which stream of water travels farthest? How does it work? WATER PRESSURE is the key to the answer. The water near the bottom of the carton has the force of all the water above it pushing it out. The water near the top has very little water-and therefore pressure-above it. This demonstrates water pressure from the sides. Next, punch a hole in the bottom of each can (small and large) 2cm from the bottom of the cans. Cover the holes with a strip of tape. Fill each can with water to the same depth (e.g. 5cm, 2 inches, deep in each can). The larger can will hold more water than the small can. Put both cans in the sink or bathtub. Pull off the tape at the same time. Which stream goes farther? (The streams should be the same length.) The depth of the water makes the pressure greater, but the amount of water doesn't. This demonstrates water pressure in downward a direction.

Next, using a fish bowl filled with water, demonstrate water pressure in upward direction by using a two liter bottle with hole in the bottom. Stick bottle in fish tank and watch the water flow upward.

Now you are ready to begin your lesson on water pressure because you have demonstrated that a fluid exerts a pressure in all directions. If an object is placed in a bowl of water, pressure is exerted on all sides of the object. If, however, one side of the object is not in contact with the water, pressure is not equal on all sides. In this activity you will see what happens when the pressure of a liquid is not the same on all sides of a submerged object. To do this activity follow the steps below to learn more about the pressure of a liquid. 1. Fill a drinking glass with water. 2. Fill a bowl or basin with water. 3. Place the metal jar lid under the hollow tube. Now, keeping both objects together, place them in the bowl or basin of water. (Be sure to hold them together, otherwise, the can will turn on its side. 4. Does the plate sink to the bottom? Explain your answer. 5. Slowly pour water from the drinking glass into the hollow tube. At what point does the jar lid sink to the bottom?

ANSWERS 4. NO. Pressure exerted by the fluid (water) pushing upward on the jar lid is greater than pressure pushing down on it. Because there is no water in hollow tube, there is no water pressure. Water pressure on all sides of the object isn't equal because one side isn't in contact with the water. 5. The jar lid sinks to the bottom when the level of the water in the hollow tube is equal to the level of water in the bowl or basin.

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LIQUID CONDUCTORS

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Objectives

1. Students will construct a circuit tester.
2. Students will predict what liquids are electrical conductors.
3. Students will test and identify liquid electrical conductors and non-conductors.

Apparatus Needed (for each group of four students)

*4 D batteries
*4 battery holders
*1 bulb holder
*8 brass electrical clips
*2 Fahnestock clips
*l l 1/2V miniature bulb
#20 bare copper wire as needed
large covered containers
markers
labels
plastic tumblers
vinegar
salt
ethyl alcohol
sugar
baking soda
distilled water
tap water
lemon juice
safety goggles
paper towels
activity sheet

Recommended Strategy

This activity should follow the study of "series" and "parallel" circuits; the teaching of how to construct a circuit tester; and the testing of solids for their ability to conduct electricity.

Advance Preparation:

-Organize materials in a shoe box or tray for each group of three to four students.
-Test the batteries and bulbs to make sure they work. Have replacements available.
-Make a circuit tester for liquids and have it on display for students to use as a model for making their circuit tester. (Circuit tester should be a series circuit made of four D batteries with the Fahnestock clips as electrodes.)
-Prepare solutions of salt, vinegar, baking soda, sugar, lemon juice, and ethyl alcohol in distilled water. Use your own judgment as to the proportions; the liquids need only be strong enough to light the bulb in the tester. Store the solutions in clearly labeled, covered containers.
-Prepare an activity sheet for recording observations. Activity sheet should include columns for recording the names of liquids tested, student predictions, and observations.

Doing the Activity:

l. Students write the names of liquids to test in chart (activity sheet).
2. Students predict if the liquids will or will not conduct electricity. Prediction is recorded.

3. Circuit tester is made using teacher's tester as model.
4. Each tumbler is labeled with the name of one liquid.
5. Students are reminded to WEAR SAFETY GOGGLES. At least 3 cm of one liquid is poured into the correct tumbler. The clips of the tester are put into each tumbler at equal depth and equal distance apart. Observations are recorded.
6. Testing liquids will need some guidance from the teacher. For best results, the flat sides of the clips should face each other. The liquids should not be mixed, and the clips should be cleaned between tests.
7. Discuss:
   a. What liquids will allow the bulb to light?
   b. What liquids will not allow the bulb to light?
   c. Does the bulb glow with the same brightness with each liquid?
   d. Are there any changes in the clips when you are testing?
   e. Did you notice anything happening in the liquid when you were testing?
8. Record conclusions on overhead or chalkboard.

Optional Activities:

l. Have the students repeat the activity using liquids brought from home such as coffee, liquid soap, orange juice. DO NOT USE CAUSTIC, CORROSIVE, OR POISONOUS LIQUIDS.
2. Interested students may advance into the study of acids, bases, and salts.
3. Challenge students to design another type of conductivity tester.

*These materials can be ordered from:

Delta Education Inc.
P.O. Box M
Nashua, New Hampshire 03061
1-800-258-1302

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Liquid Pressure

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Objectives:

To understand Pascal's Law.
To understand Boyle's Law.
To show that water is a virtually incompressible liquid.
To understand Archimedes' Principle.

Apparatus Needed:

Rectangular bottle, 1 cork stopper, 2 rubber stoppers with opening in the middle, open ended glass tube, Listerine bottle, gallon jug, hammer, clear plastic dishwashing liquid bottles (Ajax or Palmolive) with tops, medicine droppers, water, food coloring, hot water bottle, 4 meters of plastic tubing, C-clamps, metal extension rods, meter stick, rope, 30 cm. square board, swing structure approximately 2 meters tall made of 2"x4" wood with 60 cm. square 3/4" plywood board at top with holes for rope drilled at corners, 4 weights (14.3 lb. exercise weights were used in this mini-teach), 20 cm.x50 cm. plywood board.

Recommended Strategy:

Put glass tube through stopper. Fill rectangular bottle with water. Place a few drops of food coloring in water. Put stopper in top of bottle. Pass bottle around class. Have students note what happens when the sides are squeezed. Repeat this procedure with the Listerine bottle. Have the class note the results of squeezing this bottle. Ask questions as to why this happened.

Fill gallon jug with water. Put cork stopper in top of the jug. Compress the water by pounding stopper into the jug with a hammer. The increased water pressure should cause the jug to break. Explain that this illustrates Pascal's Law.

Show the class a Cartesian Diver model made from plastic soap bottle and medicine dropper. Explain how to make one by filling the bottle with water and medicine dropper with just enough water so that head of dropper floats. Dropper should dive when bottle is squeezed. It should return to the top when pressure on bottle is released. Let each class member make a Cartesian Diver. Explain that Pascal's Law, Boyle's Law and Archimedes' Principle are illustrated in the Cartesian Diver.

Fit plastic tubing through rubber stopper. Fit funnel on other end of plastic tubing. Fill hot water bottle with water. Color water with food coloring. Secure rubber stopper in opening of hot water bottle so that water does not leak and stopper does not pop out. Place bottle on top of 60 cm. square board at top of swing structure. Run rope through 30 cm. square board. Place it on top of water bottle. Run the rope through holes in corners of the 60 cm. square board. Place 20 cm.x50 cm. board at end of ropes for the swing. The C-clamps should be attached to the lab table with extension rods holding the funnel and plastic tubing about 3 meters above the height of the hot water bottle. Height of water in tube with board on top of water bottle should be calibrated as point zero. Place one weight in swing. Measure height of liquid in tube. Mark off point on tube. Continue placing weights in swing. Record weight and height of water with each addition. Make a graph of the weight as it changes the water height. Have a student sit in the swing. Measure height of liquid in tubing. Put this point on the graph. Draw a line connecting points to see if the line is linear or curved.

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Bathtub Physics - Density, Buoyancy and Flotation

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Objectives:

Understand Archimedes' Principle, flotation and the reaction of bouyant forces. Explain the relationship between density and flotation.

Apparatus needed:

triple-beam balance
hooked mass 50g
spring scale
string
500-ml graduated cylinder
800ml beaker
water
bathtub (large container or pool small)
gallon jug
salt solutions: Use Epson Salt
1. sea water 3.5g of salt per 100cm^3
2. Great Salt Lake 20g of salt per 100cm^3
3. Dead Sea 25g of salt per 100cm^3

Recommended Strategy:

1. Record the weight of an hooked mass with a spring scale. Fill a graduated cylinder half-full of water and record the level of water. Hang the mass from the spring scale and lower the object until it is submerged in the water in the graduated cylinder. Record the weight of the object in the water and the amount of water displaced.

2. Use a bathtub to find a student's volume. Fill the tub half-full and mark the level. Submerge a student and mark the level of the water. Once the student is out of the tub, use a measuring device- large graduated cylinder, gallon jug - to fill the tub to the higher mark. The amount of water needed to do this will be equal to the students volume.

3. Place an uncooked egg in a 800cm^3 beaker half filled with water. Next place the uncooked egg in each of the containers of salt solutions one at a time. Make careful observations of what happens in each solution and record your data.

References

Floating - A Key To Survival **Science and Children** October 1980 33-35.
Conceptual Physics Paul Hewitt

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How To Make Water Run Uphill

Team Teach

MEMBERS:

Edgar Boyd
Dorothy Foreman
Earnest Garrison

Objective:

When asked, each student will be able to explain orally, or in writing how water can run up a hill.

Apparatus needed:

1. large bucket
2. 36" glass (hollow) rod
3. 1,000 milliliter glass florence flask
4. ring stand
5. food coloring (blue or green)
6. One hole rubber stopper
7. propane torch
8. matches
9. 2 gallons of water
10. Safety eye glasses

Recommended Strategy:

Assemble apparatus for this demonstration as shown in the drawing below.

```
                   lllll
                   l   l
                   l   l      FLASK
                   l   l
                   lllll
_____________________|_______________________
_____________________|_______________________      TABLE TOP
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                ...........
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                  |     |          BUCKET
                   |   |
 FLOOR             .....
=================================================================
=================================================================
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Add the food coloring (blue or green) to the water in the bucket. Heat the flask with the propane torch until air bubbles stop coming out of the glass tubing in the bucket. Turn off the propane torch and allow the flask to cool for a few seconds. You should observe water from the bucket moving up the glass tubing and filling the florence flask. You have now made water run up a hill.

Conclusion:

The principle that explains your demonstrations is atmospheric pressure. The atmosphere exerts a pressure of 14.7 lbs. per square inch (15 lbs.) at sea level. When the flask was heated, the expanding gas (air) in the flask was forced out and down the glass tube. As the flask cooled, the atmospheric pressure forced the water in the bucket to go up the glass tubing and replace the air that was forced out of the flask.

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Mathematics/Physics

Fish and Clip

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Ravenswood
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Objective:

Have first grade students understand some of the characteristic of magnets.

Materials:

For each group:

2 trays

30 big paper clips- big fish

50 little paper clips-small fish

15" string, tied to any type of magnet, attached to dowel or non-sharp pencil fishing pole.

	Number of large fish	**Number of small fish**
Trial #1		
Trial #2		
Trial #3		
Trial #4		
Trial #5		
Total		
Average		

-

-

Strategy:

Step 1: Through story telling technique some volunteers will come out to do an activity that will show the class the main characteristic of magnets. The characteristic is that metal contains iron will be attracted by magnets.

Step 2: For the following activity students should work in groups of 2-4 and take turns fishing within their groups. When calculating averages, express answers in whole fish with remainders dropped. Use the table provided for the activity.

Procedure:

(1) Put 30 big paper clips on one tray and put 50 small paper clips on the other tray.

(2) With the fishing pole, students fish for big paper clips and record the catch.

(3) Fish for small clips and record the catch.

(4) Perform 5 trials for (2) and (3).

(5) Find the average number per catch for both small and large clips. Briefly review the concept of average if necessary.

Performance Assessment:

Students will be assessed for their understanding about magnet through the following discussion.

(1) Did the magnet attract more small clips or more large clips? Why?

(2) Did any group catch the same number of small or large clips in each of their trials? Why or why not?

(3) Since each group is using a magnet of the same size, did any two or more groups catch the same number of either small or large clips in any trials? Why or why not?

(4) If the activity is being done differently, such as by wrapping two magnets of the same size together, what kind of result will be expected?

Conclusions:

Even if magnet of the same size and shape, they may vary in magnetic strength.

References:

None.

Janet M. Sheard - West School

Series and Parallel Circuits

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West School
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Objective(s):

These lessons are designed for fourth-sixth grade students to do for five-seven days. Each student will be able to:

1. identify man's needs and uses for light in a time line.
2. understand that many people choose science as a career and devote their entire lives studying it.
3. identify what contributions Ben Franklin made to electricity.
4. draw and explain how to build a closed and an open circuit.
5. construct a simple series and parallel circuit.
6. understand the meaning of and use of the following vocabulary words: D-cell battery, current, closed and open circuits, protons, electrons, and neutrons.

Extension:

The students will be able to:

1. construct and attach a switch to a series and/or parallel circuit.

Materials Needed:

For two students to create a series and parallel circuit

1 D-cell battery
4 six inch pieces of wire
1 battery holder with Fahnestock clip
2 bulb holders
2 bulbs
list of electrical symbols used to represent a battery, wire, and switch
student science journal

The following materials are needed to create a switch for one or two students

2 6-inch pieces of wire
1 paper clip
1 3"x 5" index card
2 No. 3 brass paper fasteners
2 brass paper fastener washers
2 Fahnestock clips

Material Needed for Extended Activity:
1 roll 3/4" masking tape

Strategy:

Initial Motivation:

1. Brainstorm with the students to find out what previous knowledge they have about electrical currents and circuits.
2. Prepare a time line entitled "Time Line of Man's Needs and Uses of Light" for each student. Put the dates in sequential order by placing the correct number between the parentheses.
   ( ) FLUORESCENT LIGHTS: 1940 A.D.
   ( ) FIRE: 400,000 B.C.
   ( ) FLASHLIGHT: 1898 A.D.
   ( ) SUN
   ( ) GAS LAMP: 1700 A.D.
   ( ) ELECTRIC LIGHT BULB: 1880 A.D.
   ( ) KEROSENE LAMP: 1800 A.D.
   ( ) TORCH: 6000: B.C.
   ( ) CANDLE: 1300 A.D.
   ( ) OIL LAMP: 100 A.D.
3. Read highlights from a biography of Benjamin Franklin.

First Activity: Create a basic simple circuit.

1. Give each pair of students a box with a D-cell battery, 1 6-inch wire, and a bulb. Explore. "How can you make the bulb light?" Draw at least three ways the bulb lit in a science journal. Choose several illustrations to draw on the board.
2. Discuss the connection between the meaning of a current and a circuit.

Second Activity: Create a simple circuit.

1. Pass out another 6-inch wire, a battery holder, and 1 bulb socket Ask, "Can you make the bulb light?" Explore. Draw several illustrations on the board and in individual science journals. Share and discuss with the class.
2. Reinforce the meaning to make clear the distinction between circuit and current.

Third Activity: Create a series circuit.

1. Pass out another 6-inch wire and another bulb and bulb holder. Ask, "Can you make the bulbs light?" Explore. Draw on the board and in science journals several ways the group discovered to make the bulbs light. Share and discuss with the class.
2. Introduce the secret language of electricity. Draw an illustration on the board using electrical symbols.

Fourth Activity: Create a parallel circuit.

1. Give each student another 6-inch wires. Ask, " Can you make the bulb light?" Explore. Share illustrations and discuss the techniques used to make the bulb light.
2. Identify the name parallel circuit.
3. Pass out the page with the secret language of electricity. Use these symbols to illustrate a simple way to draw a parallel circuit without using pictures.

Extension for the lesson:

1. Attach a switch to the series and parallel circuit by using previous acquired knowledge.
2. Research and prepare a presentation about Michael Faraday, Joseph Henry, Thomas Edison, and Samuel Morse. The teacher should design an information page to collect data for report.

Performance Assessment:

Basic: The student will be able to:

construct and draw an electrical circuit.
recognize electrical symbols.

Proficient: The student will be able to:
illustrate one example of a series and parallel circuit using electrical symbols.
write a definition of a series and parallel circuit.

Advanced: The student will be able to:
draw two illustrations of a series and parallel circuits using electrical symbols with the illustrations.
teach a new student how to create an electrical circuit.
apply the function of an electrical current to another kind of circuit.
write a detailed explanation of an electrical circuit using electrical symbols.

Conclusions:

The students will be able to:
1. explain the difference between a closed circuit and an open circuit.
2. explain the difference between a series and parallel circuit.
3. explain the advantages and disadvantages of series and parallel circuits.

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Stephen W. Ha - James Ward School

Simple Circuitry and series circuit

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Objective(s):

Note: This mini-teach is designed for a 3rd-grade or 4th-grade class.

(1) Explain the elements that are required to build a basic electrical circuit.

(2) Demonstrate and describe a series circuit.

Materials Needed:

A piece of 10-foot wire, a bag of candy, chalks, blackboard, work papers, and five labels (battery, switch, and 3 light bulbs).

Strategy:

Brainstorming (approximate 5 minutes)
- Ask students what they know about an electrical circuit and what they need in order to construct a basic electrical circuit. Then Write down all responses on the board.

- Discuss all responses that are related to the topic of circuitry and lead to the conclusion that a basic electrical circuit must contain a power source, electrical wire, a switch, and a lighting device (a light bulb in this specific lesson).

- Draw a simple circuitry on the board (use D.C. battery as power source) and make sure students learn all symbols being used in a circuitry.

Activity

(1) Let students know they are going to do an activity to help them understand what is a series circuit. Ask for five volunteers for the activity.

(2) Tell the class the series circuit they are going to see will contain 5 components and each student will represent a component after I have put a label on each of them. The components are a battery, a switch, and 3 light bulbs.

(3) Have the five volunteers facing the class and standing in a straight line across the room. The two being labeled battery and switch should stand on each end of the line in a way that, as students look at them, the person

represents the battery should be on the left end and the person represents the switch should be on the right end.

(4) Bring out a 10-foot wire and have each volunteer using his/her right hand hold the wire up. Then they will form a circle, i.e., the battery and the switch should be right by each other now.

(5) Bring out a bag of cookies and tell the class that each cookie will represent the electrons in the current that are getting ready to move along with the current.

(6) Give a piece of cookie to the battery. After he/she have eaten the cookie, he/she will grab the wire with his/her free hand. This means that the battery is full of charge now and the current is getting ready to move through the wire to the next component, as long as a closed path is present.

(7) Then going clockwise I will ask the next component the question "Would you eat a piece of cookie so that the current can pass through to the other side of the wire?" If the answer is "No", any volunteers with his/her left hand holding on the wire must make sure his/her left is off the wire now, and the activity should start all over again from step 6 because there is an open path in the circuitry.

(8) If the answer is Yes" and the current component is not the switch, he/she should eat the cookie, put his/her left hand on the wire so that the current can pass through the component, move to the other side of the wire and go back to step 7. Otherwise, the switch should consume the cookie and grab the end of the wire from the battery. The result is we just complete a series circuit.

Performance Assessment:

A work paper will be passed to each student to work on the material they just learned. They should now be able to identify the standard symbols being used in electrical circuitry. They should also be able to construct a series circuit of their own.

Conclusions:

A series circuit is simple to construct but it is hard to troubleshoot in case a fault is present.

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Barbara J. Baker - Doolittle West School

About Magnets

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Objective(s):

This lesson is designed for second grade level students. Conduct simple experiments and observations and explain what was discovered. Designing a magnet from a sewing needle. Making a compass. Understanding the vocabulary terms.

Materials Needed:

Magnets, sewing needles, cheerios cereal, nails or screws paperclips, hair pins, sand, water, paper cups, large container, cork, contrasting paper towel to place the sand on for example, if you use white sand, use a brown paper towel

Strategy:

Students will be placed in cooperative groups to work the procedures and to study the following vocabulary words:

magnetic fields	magnetic force
magnetic strength	magnetized particles
north & south poles	compass
procedure	compare
repel	contrast
attract	iron

Each group will have a recorder and presenter who will work together to illustrate the phrases by drawings or explanations which will be shared with the whole class.

By dragging the magnet across the sand, students will observe that sand often contains particles of iron.

After the cereal has been crushed, magnets will be dragged across it to see if any iron from the cereal adheres to the magnet.

Magnets will be placed in water and later attract pins to test if water interferes with the magnetic field, the same magnet will be dragged over the sand to compare and contrast the findings.

Moving the magnet across the needle will magnetized the needle, the needle will be inserted into a cork and placed in the large container of water to observe how this handmade compass is working

Performance Assessment:

Students should demonstrate comprehension through visual observation of how the students completed the procedures. The comprehension of the terms and the use of these terms with 95% or higher accuracy. If a magnet or a compass is brought in for show and tell, the student is showing retention and continued interest in magnets.

Conclusions:

The earth and many things in the earth are magnetic.

References:

Off the Wall Science, A Poster Series Revisited
365 Science Projects
Encyclopedia of Science Projects

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Mathematics/Physics

Magnet Muscles

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Objective(s):

Students will be able to recognize the strength of a magnet, what part of the magnet is the strongest, and what is a magnetic attraction.

Materials Needed: (For an entire class)

Several bar magnets and/or magnets of different sizes and shapes, several magnetic objects (paper clips, nails, iron filings, etc.), several nonmagnetic objects (plastic, paper, coins, etc.), pens and/or pencils, data-capture sheet - one per student (pages 13, 15, 23, 72, 82 92), 20 small nails, large nails, 20 metal paper clips, several compasses, a table or flat surface, wooden rulers and construction paper.

Strategy:

1. The teacher will introduce the topic by explaining some basic facts about magnets. Students will be allowed to observe a magnet.
2. The teacher will also explain the concept of a magnetic field. The students will observe the teacher place a bar magnet under a piece of thermal fax paper. A student can be chosen to come up and sprinkle pieces of iron fillings on the paper. Observe to see what will happen. Then teacher can then discuss the magnetic field of a magnet.
3. The teacher will explain the scientific method, which will be used in the lesson.
4. Cooperative Learning Strategies will be explained prior to placing students in cooperative learning groups.
5. Once each group has been placed, the groups will be given the rules for each learning station. Students will have 20 minutes to formulate a hypothesis, test the hypothesis and come up with a conclusion for each station. Predictions and outcomes are to be in written format by the stenographer in each cooperative learning group.
6. Each group begins to research.

STATION A ATTRACTION ACTION

1. Using a bar magnet, select one object at time to see if it is magnetic.
2. Record your findings on the data-capture sheet provided.
3. Once you have tested all of the objects provided, be creative and find five more objects to test for magnet properties.
4. Repeat step 2.

STATION B MAGNETIC MUSCLE

1. With the 20 nails make a pile on a desk or other hard surface.
2. Choose one magnet and place it in the pile of nails.
3. Slowly lift it out of the pile and record the number of nails it picks up on the data-capture sheet provided.
4. Repeat steps 2-3 with the remaining magnets.
5. Replace the nails with the 20 paper clips and repeat steps 2-4. Compare your results from the first experience.

STATION C MAGNETIC MAP

1. Place the bar magnet in the middle of the piece of paper and trace around it to mark its position.
2. Put the compass on the paper near the magnet. Draw and arrow between the compass and the magnet showing the farthest point where the compass needle is affected by the magnetic field.
3. Repeat step two several times all around the magnet.
4. Once you have completed step three, you will be able to see where the magnetic field exists, where it is the strongest, and where it is the weakest.

STATION D NEIGHBORLY NAIL

1. With the large nail try to pick up some of the smaller nails or paper clips. Observe what happens and record on data capture sheet.
2. With one end of the bar magnet, stroke the nail 25 times in the same direction.
3. Try again to pick up the small nails or paper clips with the newly magnetized nail. Observe what happens and record on data-capture sheet.
4. Carefully throw the magnetized nail against a hard surface.
5. Try one more time to pick up the small nails or paper clips with the nails. Observe what happens and record on data-capture sheet.
6. Repeat this experience using iron fillings instead of nails or paper clip. Observe what happens and record on data-capture sheet.

Performance Assessment:

1. teacher-made test
2. oral- group discussions
3. magnetic journals

References:

1. Boak, Rebecca & Raymond Gabaldon. Magnets. Columbia Education Center's Summer Workshop. May 1994.
2. Bouchier, Alfons. Magnetic Fields and Bermuda Triangles. Los Alamos High School, Los Alamos, NM. 1994.
3. Feigen, Mel.. Magnetism and Electricity. Teacher Created Materials, Huntington Beach , CA., 1994.

Electrostatics

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Objectives:

The main objective of the Mini-teach is to show Primary students that there is electricity in all matter.

Materials Needed:

- Van DeGraff Generator
- Rabbit's Fur
- Plastic Rod 12-18 inches long
- Tape
- Small Paper Scraps
- Puffed Rice
- 5 Balloons
- Glass Rod 12-18 inches long
- Piece of String 15cm long
- 3 Pieces of String 35cm long
- Salt and Pepper
- Mashed Potato Flakes
- Electroscope
- Small stream of running water (if available)
- Enough for the class or group-pop cans, 1 in x 1/2 in, aluminum foil strips combs, foam plates, foam cups, pie plates.

Strategy:

Using the Van DeGraff generator place the pie pans face down on top. Put the generator on have students stand back and watch the plates sail off. If you have older students, they can form a chain to see how far out the charge will travel. Always discharge the generator with a stick when you turn it off. The students can also try one at a time to place their hand on the generator, while they stand on a milk-crate to insulate them from the ground. See what happens to their hair.

After the demonstration, the students go to stations. Your options to set this up:

1) Balloons-Tape one end of 15cm string to a table top. Charge a balloon by rubbing it with the fur. Hold the balloon over the thread, don't touch, the thread should move towards the balloon. Tie a 35cm string to one balloon, hang it on something freely, tie the other string around another balloon, and hang it about 5 cm. away from the first. What happens? Charge one of the balloons, what happens? Charge the other balloon, what happens? The first time they should attract, the second time they should repel. Charge a balloon and see if you can get it to attract to the wall. Tie the last 35cm string around a balloon and hang it up or tape it to a table. Charge the balloon and place your hand close to the balloon, don't touch, it should follow your hand.

2) Combs-Comb your hair very hard. Place the comb near one of the above items. The static electricity will make the item attracted to the comb. Try with a number of different items. Come up with your own ideas. Comb your hair again and place the comb near the running water. The stream of water will either repel or attract (the water really moves).

3) Electroscopes-Rub fur on the bottom of the foam plate, place a pie pan on to the foam plate. Lightly touch the pan to charge it. Bring the charged pan over to the Electroscope. The leaves of foil will repel because of like charges.

4) Make Electroscopes and Electrophorous-Glue a foam cup on top of a pie pan, as a handle. Use two foam plates, turned upside-down, to rub the pan on to charge it. Tape a pop can to the top of a foam cup. Take the foil strip and loop it loosely over the tab of the can.

Performance Assessment:

The assessment would probably be teacher observation. Did the student follow directions? Did the student participate in stations? To what extent was his participation? You could also have them record their observations and results in their journals. A rubric would be easy to make for this exercise using:

4=followed directions, used all stations provided, recorded all information requested.
3=followed directions, used most of the stations provided, recorded most of the information requested.
2=followed most of the directions, used some stations, recorded some information.
1=followed some directions, used few stations, recorded little information.
0=nothing done.

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Electrostatics

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Objective:

High school students will identify two types of charges and will observe the charging of with various objects by friction, conduction, and induction.

Materials:

For each group: Magic tape, golf tube, cat fur, wool, electrophorus, salt, pepper, cereal, slates and markers.

For teacher use: Van de Graff generator, spectral tube, mini electrostatic precipitator (made from plastic 2 liter bottle with two bands of aluminum foil and pins with paper clip leads to connect to Van de Graff).

Strategy:

Part 1: Give each group tape. Tell them to tear off two pieces about the same length. Have students stick the tape to the table side by side, rub them and then pull them off quickly. Tell students to record what happens when they bring the two pieces of tape close together and encourage them to experiment with the tape trying various pulling speeds, lengths and thicknesses and record their findings on the white boards with markers. Bring one member of each group to the front of the class and share results. The class should arrive at a consensus that there are two distinct charges and that rubbing the tape apart produces a charge that repels and rubbing tapes on top of each other produces a charge that attracts. Next, hand out to students the golf tubes and wool cloth and tell them to charge the tubes using friction. Get them up, out of their seats and tell them to find a favorite attractive object in the room to share with the class. (Have various materials in the room: cereal, salt, pepper, balloons, etc.) When students find their object tell them to sit down. Call them down and have them share their findings with the rest of the class. Reemphasize to the class the fact that and object can be charged by friction and can attract objects.

Part 2: Ask students if they think that they can get heavy things to move with a charged tube. Have them check their neighbor and vote on their white boards. Post the tally. Then, charge a golf tube and bring near a 2 x 4 board balancing on a spoon. When it moves and students are mystified, inform them how strong electrical forces are compared to gravitational forces. Ask students to find out if electrical forces are strong enough to snap charges from neutral objects. Give each group an electrophorus and tell them to charge the bottom plastic plate and then place the neutral pan on top of it. Have them pick up the neutral pan by the handle and bring it near an object to see if it is charged. Note student observations and then instruct students to repeat only this time have them touch the pan with their finger before lifting. A charge should snap off and be heard and felt. Ask if the pan was charged in the first case and then ask if it was in the second case. Students should realize that touching the pan helped the pan to become charged. Illustrate the process of induction on the board. Then, call upon two student volunteers to illustrate this one more time in front of the class. Shut the lights off and hand one of the volunteers a spectral tube. When the charged plate touches it, it should glow. Mention that this glow is seen because the tube has molecules of gas that are easier to excite than air molecules. Then, bring the volunteers over to the Van de Graff generator and ask one to stand with one hand on the top of the generator and hold the other student's hand. Turn on generator and charge students. Have another one come up and join the chain. Illustrate the difference between charging by conduction, induction, and charging by friction.

Assessment:

Show students the 2 liter bottle electrostatic precipitator. Point out the features of design. Burn the incense and turn on the precipitator. Ask students to explain how the smoke is trapped by the precipitator.

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Batteries and Bulbs

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Objective:

Pupils will be exposed to the uses of batteries and bulbs. Pupils will be able to explain the difference between series and parallel circuits.

Materials Needed:

batteries
bulbs
wire
2 switches
6 sockets
plywood 16"x24"

Strategy:

Pupils will have hands on experience with the batteries and bulbs. They will have to make series circuits with one wire and then two wires. The same will apply to a parallel circuit. The teacher will make two models on the plywood; one will consist of three sockets wired together to represent a series circuit. The other will also consist of three sockets wired together to represent a parallel circuit. Each will be controlled by their own switches.

Performance Assessment:

Pupils will be able to light bulbs with the batteries using the different combinations. Also while the teacher holds up the example she/he has made on plywood. Pupils on a sheet of paper will tell the teacher which example is the series circuit and which one is the parallel circuit.

Conclusions:

Students will have a better understanding of the power of electricity and batteries.

References:

SCIENCE WITH BATTERIES
BY Paul Shipton
Publishers: EDC PUBLISHING

WORLD BOOK ENCYCLOPEDIA
Publishers: WORLD PUBLISHING COMPANY

AUTHOR REFERENCES

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Electromagnets

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Objective:

The students will make an electromagnet and determine the strength of the electromagnet.

Materials Needed:

Small Compasses
Three feet of insulated copper wire per person
Six-volt battery
Size D batteries
Battery Holders
Pieces of Cardboard
Nails (3 inches or longer)
Paper clips, tacks, pins, or other small magnetic objects
Iron filings
Salad oil
Glass or plastic cylinder (100 ml)
Wrought iron stand

Strategy:

Activity 1

Students will work in pairs. Each pair of students will receive a baggie containing materials needed. Allow the students ten or fifteen minutes to explore and manipulate the materials. Have one student from each group connect their compass with wire through the holes in the cardboard. Insert the wire through the Fahnestock clips on both ends. Place the wire over the compass. What happens and why?

Concept:

The electrical current flowing through a wire will create a magnetic field. This magnetic field causes the needle to turn at a right angle to the wire. Reverse the connections to the battery, thus reversing the direction of the current flow, and the needle will point in the opposite direction.

Activity 2

Using the same bag of materials, the pairs of students will begin wrapping the wire around the nail in the same direction until a foot of wire is left at both ends. Insert the end wires into the Fahnestock clips. Hold the electromagnet over a small pile of paper clips, tacks or other small metal objects. How many objects does your electromagnet attract? Take the wire off the battery terminal, and the tacks will immediately fall off.

Concept:

The current passing through the wire produces an invisible magnetic field. When the current is cut off, the magnetic field disappears, then the molecules of the iron return to their helter-skelter position and the nail loses most, but not all, of its magnetism.

Performance Assessment:

As a result of the electromagnet mini-teach, the sixth grade students will be able to describe the characteristics of a magnet and an electromagnet. Both attract metal and have magnetic fields; the electromagnet needs an electrical current.

The students will be able to make an electromagnet with a wire, a battery, and a nail.

The students will be able to test the strength of the electromagnet by using more coiled wire and additional batteries and nails.

Conclusions:

In activity 1 we found that electricity can produce magnetism and magnetism can produce electricity. The opposite ends or poles of magnets are attracted to each other and like ends repel.

In activity 2 we found that current through a wire produces an invisible magnetic field. When the current is cut off, the magnetic field disappears, then the molecules of the iron return to their helter-skelter position and the piece loses most, but not all, of its magnetism.

References:

Safe and Simple Electrical Experiments. Rudolf F. Graf. Dover Publications, Inc.,N.Y., 1964. pps. 86-88 and 93-94.

Be a Kid Physicist. William R. Wellnitz, Ph.D., Tab Books. McGraw-Hill, Inc., Blue Ridge Summit, PA. 1993. p, 82.

Science Projects About Electricity and Magnets. Robert Gardner. Enslow Publishers, Inc., N.J., 1994. pps. 72-82.

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Electromagnets

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Objectives:

Grade Level: 3-4

The students will make an electromagnet that will attract a metal object.

The students will increase the strength of an electromagnet so that it will attract an increased number of metal objects.

The students will compare the properties of magnets and electromagnets.

Materials Needed:

For 20 students.

10--20 inch strips of insulated copper wire, 1/2 exposed on each end
10--40 inch strips of insulated copper wire, 1/2 exposed on each end
15--size "D" batteries
1--battery holder for 2 "D" batteries
10--compasses
25--iron nails, 4" long
1--box of paper clips, approx. 300
masking or transparent tape
iron filings
5" x 7" index card or clear transparency

Strategies/Activities:

Activity #1:
Give each pair of students one battery, iron nail, 40" copper wire, and about 30 paper clips. Have them, using only the nail, try to pick up as many paper clips as possible. Discuss methods and results. Then instruct them to wrap the copper wire around the nail ten times leaving 5-6 inches of wire free on each end of the nail. Attach one end of the wire to the negative pole of the battery. Tape securely and then touch the other end of the wire to the positive pole of the battery while their partner uses the nail to pick up paper clips. Then release the wire from the positive pole of the battery. Discuss methods and results. Record the number of paper clips picked up by the magnetized nail by each group.

Concept: Electric current flowing through a wire creates a magnetic field which caused the iron nail to become a temporary magnet. When the electric current is cut off, the nails loses its magnetic property and the paper clips fall off.

Activity #2:
Elicit ideas and suggestions from students on how they can make the nail pick up more paper clips. Possible ideas are to: 1) use more wire; 2) use more

batteries; 3) use more nails. Break students into groups of four and let one group test the idea of using more batteries; another group using 2-3 nails; a third group using more wire, wrapping the nail 15-20 times; and another group wrapping the nail 30-40 times. Reconnect the circuit and pick up as many nails as possible. Record the results of each group and discuss results.

Concepts: The strength of an electromagnet can be increased by using more batteries and/or more wires. Using more nails will increase the electromagnet's capacity to hold more paper clips, without necessarily increasing the magnetic force.

Activity #3:
Have students work in pairs. Give each student a 20" length of wire and a compass in addition to their battery. Have them secure one end of the copper wire to the negative pole of the battery. Have their partner hold the looped center of the wire over the compass and they are to observe what happens to the compass needle when the other end of the wire makes contact with the positive pole of the battery. Repeat this process, but with a slight variation: attach the wire to the positive pole of the battery first, then, holding the looped end of the wire over the compass, complete the circuit touching the other end of the wire to the negative pole of the battery. Observe how the compass needle reacts. Discuss observations. Repeat if necessary.

Concept: Electromagnets have poles which can be reversed when the path of electricity is reversed. This is not a characteristic of regular magnets.

Activity #4:
This is a teacher demonstration in which the students will observe what happens when iron filings are sprinkled over an electromagnet. Place two batteries in a battery holder and connect the end wires to the end wires of an electromagnet (nail wrapped with copper wire). Place them on the overhead projector and place the clear transparency over the electromagnet. Slowly sprinkle iron filings over the transparency and observe what happens to the iron filings. Discuss observations.

Concept: Electromagnets have lines of force.

Assessments:

At the conclusion of the mini-teach, the students will be able to answer thee following questions:

Name 3 ways in which magnets and electromagnets are alike.
(Have poles, attract metals, have lines of force)

Name 3 ways electromagnets differ from magnets.
(Electromagnets need electricity to work, the poles of electromagnets can be reversed, the strength of electromagnets can be increased)

List 2 ways to increase the strength of electromagnets.
(more batteries, more wire)

References:

Physical Science Activities for Grades 2-8,
Science Curriculum Activities Library

Tolman, Marvin N. and Morton, James O.
Parker Publishing Company, Inc.
West Nyack, NY, 1986

Magnetism and Electricity
Koch, Dallas
Milliken Publishing Co., 1985

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Electrostatics

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Objectives:

Although this lab is based on the lab I perform with my high school sophomores, it has been adapted for the use for grade school. It works best in dry weather such as winter. This is a set of mini-labs designed to be inexpensive (a set can be made for less than $2.00) so that the equipment can be put in the student's hands and explored. If you are interested in a complete write-up with pictures or have a question, please call me.

Materials Needed:

Plastic Tube (like PVC pipe or golf club tubes)
tiny scraps of paper
Scotch Magic tape
a piece of cloth like wool or fur
Styrofoam square 1' x 1'
A pie-tin with a styrofoam cup glued to the center (hot glued works best)

Strategy:

1. Have the students bring the end of the rod near the bits of paper. (the small bits of paper should not attract to the rod).

2. Have the students rub the plastics rod with the cloth and bring it near the scraps of paper and observe what happens. (The bits of paper should attract to the tube where it was rubbed.) Introduce the term "**neutral**" and "**charged**". We will say that something is neutral if it does not attract tiny bits of paper. We will call something charged if it attracts tiny bits of paper.

3. Now have the students bring the end of the rod that they did not rub near the pieces of plastic. (The small bits of paper should not attract to the rod where it was not rubbed.) Note: This is because the plastic is an **insulator** which does not let the rubbed on charge freely flow.

4. Have the students try rubbing other objects around the room (a comb, a pen, or whatever) to see which ones can hold a charge. (answers vary)

5. Have the students take about 15 cm (6 inches) of the scotch tape and fold the first few cm of each end sticky side together. Have them stick the sticky end down on a tabletop. Now peel the tape up quickly. Bring the tape near the small bits of paper. Is the tape charged? (it should be)

6. Have the students make another tape just like the first and bring it near the other tape where both tapes are free to swing. What happens? (they should repel)

7. Have the students make two new pieces of tape like before but this time have the students place the first one sticky side down. Have the students now place the second tape on top of the first and press down. Peel the two tapes up together THEN separate them. Bring the two tapes near each other and free to hang. What happens? (the tapes should attract)

8. Have the students hang the two tapes freely from the side of the desk. Re-rub the plastic tube and bring it near each tape. What happens? (The tube should repel the tape that was on the bottom and attract the tape that was on top.)

Now is a good time to re-group and provide the students with some content. There are two types of charges, some attract and some repel. Benjamin Franklin set the standard that when glass is rubbed with silk the glass becomes "positive" and when amber (a semi-precious stone) is rubbed with fur it becomes "negative." This is where I ask students to take it on faith that the rod became "negative." The rule for charges is opposites attract and likes repel so positive and positive repel, negative and negative repel and positive and negative attract. The idea of the atom and positive protons and negative electrons may be also introduced along with the idea of electrically polarized. (That explains why neutral objects attract to charged objects.)

9. Ask the students if the rod is negative and this tape repels, what must the charge of the tape be? (negative)

10. Ask the students if the rod is negative and this other tape attracts, what must the charge of the tape be? (positive)

11. Take the styrofoam and rub it with the cloth. Place the pie-tin on the styrofoam while holding it by the insulated handle. Touch the metal (you should get a small shock). Lift the pie-tin by the insulated handle. Now touch the metal. You should again get a shock. This method of charging is called "**induction**." (When the pie-tin was near the negatively charged styrofoam and you touched the metal with your hand, the negative charges were repelled leaving the pie-tin positive. When you picked up the pie-tin by the handle it was positively charged. When you touched it negatives from your hand were attracted and entered the pie-tin making it neutral again.

Performance Assessment:

Make a negatively charged tape by following the procedures in number 5. Rub the styrofoam with the cloth. Bring the styrofoam near the tape that is free to hang. The tape should repel. Ask the students, "What can we say about the two charges?" (They are the same. Really sharp students may say they are both negative. That's good if they can back the statement with facts, not opinions.)

Conclusion:

The conclusions have been placed after each question in parentheses.

References:

Me. See above information

Introduction To Magnets

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Objective:

The students will familiarize themselves with several different kinds of magnets. They will observe the forces of attraction and repulsion between the different poles. I will introduce and we will experiment with the forces of magnetism, electromagnetism and static electricity. This lesson can be adapted to instruct kindergarten through high school. This is a three to four week unit.

Materials Needed:

The materials needed for this introductory lesson is as follows:

A. magnets of different sizes and shapes (bar, horseshoe, etc.)
B. iron filings
C. stand for holding two magnets with a string
D. miscellaneous items; Such as, bottle caps, buttons, paper clips, coins, pencils, pens, needles, and plastic disks
E. chart paper, tissue paper and drawing paper
F. markers and crayons
G. scissors and string
H. picture charts (for visual display)
I. masking tape
J. clear plastic board, approximately 6x8 or plastic wrap
K. overhead projector machine and transparency sheet
L. batteries
M. wire
N. fur
O. plexiglass case with filings
P. compass

Strategy:

In this unit we will explore the forces of attraction and repulsion. Such as magnetism, electromagnetism, and static electricity.

Sometimes the students will work in small groups on experiments and at other times they will work individually (according to the activity and class size).

The teacher will set up the materials necessary for each experiment and the students will gather the materials that they will need for each experiment.

The strategy of the first lesson is to let the students explore and observe the magnets. They will observe the lines of force, the attraction and the repelling forces that all magnets exhibit. They will also become familiar with the poles of each magnet and observe for themselves the differences between the north and south sides of the magnet.

Each group of students will have to select from the list of materials a chart marker, magnets of different shapes, paper clips, plastic paper cut in squares, iron filings and other miscellaneous materials.

The teacher will use the overhead projector, two bar magnets, iron filings and a transparency sheet to demonstrate and compare the forces of the magnet's poles.

Each group of students will use their experience charts and markers to jot down information that they have gathered about their magnets. They will then present their data to the class.

Later, after the students have completed their observations of magnets, they can begin to experiment with them. They should label each experiment.

The next experiment is to understand how a compass works. They will find out that the earth acts like a giant magnet and attracts other magnets toward its north pole. For this experiment the children will need a bowl, sewing needle and a small square piece of tissue paper. The students will float a small piece of paper in a bowl of water, and rest a needle (that has been rubbed with a magnet) on it. When the needle is still they will mark which way it points. The students can compare their experiments with others that made needle magnets. They should find that all needles should point the same direction, which is along a north-south line.

The third experiment is to let each child make an electromagnet. For this experiment they will need a piece of wire about sixteen inches long, a nail, a C-size battery and three pieces of masking tape. The strongest electromagnet will win a prize. We can test it by observing which student's electromagnet can pick up the most paper clips.

The final experiment will be to demonstrate static electricity. The students will need a picture of snake from the MacMillian Science Activities, a large piece of tissue paper, a small wool cloth, and scissors. They must trace the snake on the paper, cut it out. Then they should rub their pen with the wool until it will begin to make the snake wiggle.

The teacher should set up experimental stations and let the children display and label their work.

Performance Assessment:

The student will be assessed as a group and individually according to whether they have completed every task asked of them. Each student will demonstrate knowledge of what each experiment is about and explain on paper and orally what each experiment demonstrates.

References:

The Usborne Book of Science Experiments, By Jane Bingham, Usborne Publishing Copyright, 1991; And the MacMillian Science Group.

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Electricity

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Grade Level: Primary Grades 1 and 2.

Objectives:

Students will correctly make a simple circuit using a battery, bulb, and a wire so that the bulb will light. (A)

Students will identify contact points in a simple electric circuit. (B)

Students will properly use a test circuit to identify conductors and non-conductors. (C)

Students will correctly construct and use a test circuit to test for conductors and non-conductors. (D)

Students will correctly connect a chemical battery that will light an LCD. (E)

Students will correctly use mechanical energy to make a bulb light up. (F)

Students will correctly use a solar cell to make a bulb light up. (G)

Materials Needed:

For a class of 20.

20--1.5v bulbs
20--D-size batteries
10 yds.--insulated copper wire, cut into 10 inch lengths and stripped 1/2 inch on each end
10--wood blocks, 1/2 x 3 x 5 inches
1 dozen--paper clips
1--hand generator
1--solar cell
06--light bulb sockets
06--battery holders
Box of small ordinary items made of metal, plastics, or fabric, money crayons, string, bottle caps, etc.
3 or 4-- phillips screwdrivers
1 dozen--thumbtacks
1--LCD chemical
2--lemons
20--Christmas tree lights, separated into individual lights leaving 3 inches of wire on both ends. Strip off 1/2 inch on each end of wire.
A light source from an overhead projector or a small lamp.

Activities:

Activity #1:
This is an exploration and an individual activity. Meets objectives A and B.

Give each student one battery and one Christmas light. Without explanation, tell them to make the Christmas light come on. Allow 5-10 minutes for this activity, then have students demonstrate and discuss ways they were successful or unsuccessful in getting the lights to come on.

Concepts: Electricity travels in a path called a circuit. Wires must be correctly attached to the battery's contact points to complete a circuit.

Activity #2:
The first part of this activity is a teacher demonstration; the second part is a student activity. Meets objectives C.

Using the test circuit (see instructions for making) review contact points on a battery. Demonstrate contact points using two batteries and show how two batteries, together, can make the 1.5 v light come on. Explain the use of a battery holder and its contact points. Demonstrate making the light come on using the battery holder.

Show students the circuit set-up and ask them why the light doesn't come on.

Student response: The circuit is not complete, or it is not a complete circuit. Accept all answers that refer to an incomplete circuit. The teacher selects an item from the mystery box and demonstrates how to complete the circuit. Have students select an item from the mystery box and attempt to complete the circuit by making the item touch both paper clips. Have them sort the items by keeping those that make the light come (complete the circuit) from those items that don't. Have students identify common properties of those items that make the lights come on.

Concept: Some materials conduct electricity (conductors) and some materials do not (insulators). Metals are conductors of electricity. When the circuit is incomplete, the path of electricity is interrupted.

Activity #3:
This is a cooperative student activity. Meets objective D. Students will work in groups of four.

Each group will need the following materials: 2-'D' batteries, 1 battery holder, 1-1.5v light bulb, 1-light bulb socket, 2 paper clips, 2 thumbtacks, 2 insulated copper wires, 6 inches ea., 1 wood block, a screwdriver.

Students are to construct a test circuit that will make the light bulb light when completed with a metal conductor from activity #2.

Activity #4:
This activity demonstrates electric power from mechanical, solar, and chemical energy sources. Meets objectives E, F, and G.

Connect a Christmas light to the hand generator; set aside.

Place the solar cell apparatus under the light source; do not turn on the light.

Take two lemons and the LCD chemical clock and place each a copper and zinc end of the LCD chemical clock into one lemon and do the same with the other lemon so that the time display comes on on the clock.

Ask for student volunteers to make the Christmas light come on using the hand generator; to make the solar apparatus work using the light source; and then the teacher disconnects the LCD chemical clock and has students re-connect it so that the clock comes on again.

Discuss with students chemical, solar, and mechanical energy and their uses.

Concept: Electricity can come from many sources, including chemical, solar, and mechanical.

Assessments:

Performance or authentic assessment is used for this topic. The students demonstrate or perform their understanding of the concepts when they make the light bulb come on, the LCD clock come on, correctly sort conductors and insulators, correctly construct a test circuit that will make the light come on when the circuit is completed with a conductor.

Extensions and teacher information:

A battery is a chemical source of electricity. This can be demonstrated by cutting a battery in half, lengthwise to show that it is made of carbon, nickel, and acid. Using a strip of copper and nickel in a beaker of acid such as vinegar, sulfuric acid, lemon juice or lemon, you can show the presence of electricity with a galvanometer. (Tolman and Martin, pp. 247-253)

Directions for making a test circuit:

Place 2 "D" batteries in battery holder. Using 2 strips of copper wire, connect one end of each wire strip to one end of the battery holder wires. Connect the exposed end of one of the copper wires to the light socket contact point. (A small screw on the light socket.) Connect one end of a third strip of copper wire to the other contact point on the light socket. You now should have 2 remaining unconnected copper wire ends. Wrap the exposed wire tightly around the end of a paper clip. Do the same with another paper clip. Secure the paper clips into the block of wood using two thumbtacks, positioning them into the wood so they do not touch and leaving a half-inch space between them. You can secure the light socket to the wood block using clay or screws. Screw the light bulb into the socket, check contact points, and test your circuit by laying a piece of metal across the paper clips to complete the circuit. The light should come on if correctly constructed.

References:

Physical Science Activities for Grades 2-8,
Science Curriculum Activities Library
Tolman, Marvin N. and Morton, James O.
Parker Publishing Company, Inc.
West Nyack, NY, 1986

Batteries, Bulbs, and Wires
Glover, David
Kingfisher Books, NY, 1993

Electricity Experiments for Children
Reuben, Gabriel
Dover Publications, Inc., NY, 1960

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Electricity

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Objectives:

This lesson is appropriate for all grades from 5th through high school. The main objective is to teach elementary electricity principles with the use of materials which are easily available.

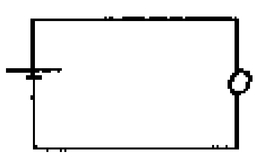
Materials Needed:

1.5 volt batteries (D cells)
3 volt bulbs and sockets
hook-up wire (thin)
single pole knife switches
3 volt buzzers
3 volt motors
battery holders for 2 batteries
These items are obtainable at American Science Center or Radio Shack.

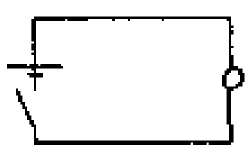
A typical kit for three students working as a group would consist of 2 batteries, 4 bulbs, 4 sockets, 12 pieces of wire (about 8 inches long and stripped at each end), 2 knife switches, 1 buzzer and 1 motor.

Strategy:

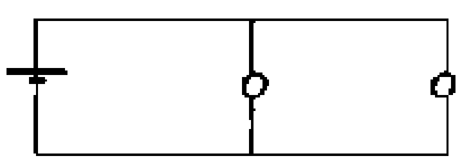
Describe and illustrate the flow of electrical current from the battery, through the wires and through a bulb. Have the students construct a simple circuit using a single bulb:



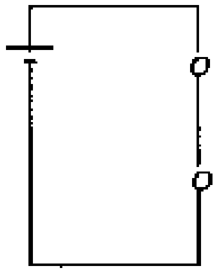
This can be followed by the introduction of a switch into the circuit to show how the light can be turned on and off.



The next step would be an explanation of parallel circuits where the electrical surrent from the battery flows with equal voltage into two or more bulbs.



After the students have hooked up this circuit, they can then hook up a series circuit where the electrical current from the battery flows first through one bulb and then through the other.



Students can then be directed to loosen various bulbs in their sockets to show that a bulb will remain lit in a parallel circuit even though another bulb may be out. This can be compared to the series circuit where the loosening of one bulb in the circuit will cause any other bulb in the circuit to go out also.

A further step would be the hook up of a parallel circuit using different components such as bulbs, buzzers and motors.

Performance Assessment:

Grading the student on his or her performance should be based on two factors:
1. The ability to construct the circuits accurately and have them work properly.
2. The ability to explain the circuits by tracing the flow of current from the battery through the various elements of the circuit.
Each of these factors should be weighted at approximately 50% of the grade.

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Resistances In Series And Parallel Circuits

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Objectives:

1. To observe the difference in illumination for a given set of bulbs when placed in series and in parallel circuits.
2. To calculate the IR drop across a network of resistances in series and parallel.

Materials:

Six flashlight bulbs and sockets, one switch for each of the two circuits, four "D" cells, masking tape, twenty 10-cm pieces of bell wire, two DC ammeters of range zero amp. to one amp., two DC voltmeters of range zero volts to five volts.

Strategies:

Activity 1. Series Circuit

1. Connect three bulbs in sockets in series with a switch, an ammeter, and two "D" cells that are firmly taped together top to bottom. Place the ammeter between the switch and the two-cell battery. Connect the negative terminal of the ammeter to the negative terminal of the battery.

2. Close the switch. Read and record the amount of current. Open the switch.

3. Reconnect the ammeter between two of the bulbs. Close the switch. Read and record the amount of current. Open the switch.

4. Reconnect the ammeter as in step one.

5. Connect a voltmeter across one of the bulbs. Be sure that the negative terminal of the voltmeter is connected toward the negative terminal of the battery.

6. Close the switch. Read and record the voltage drop. Open the switch.

7. Repeat steps 5 and 6 with the voltmeter connected across two bulbs.

8. Predict what will happen to the voltage drop if the voltmeter is connected across all three bulbs. Repeat steps 5 and 6 with the voltmeter connected across all three bulbs.

9. Remove one of the bulbs from its socket without disconnecting the socket. Remove the voltmeter. Close the switch. Record the ammeter reading. Open the switch.

10. Reconnect the circuit, so that, there are only two bulbs, and sockets in

series with the ammeter, switch, and battery. Record the current value and voltage (IR) drop across the circuit. Open the switch.

Students, this concludes our first activity. Now, let's discuss what took place.

Activity 2. Parallel Circuits

Students, the purpose of this activity is to study the properties of a parallel circuit.

1. Connect three flashlight bulbs in parallel sockets.

2. Connect 2 "D" cell batteries, a switch, and an ammeter in series. Place this in parallel with the 3 sockets. Be sure, that the negative terminal of the ammeter is toward the negative terminal of the battery.

3. Close the switch. Read and record the current value. Notice how bright the bulbs are. Open the switch.

4. Without disconnecting the socket, remove one bulb. Close the switch. Record the current value. Compare the brightness of the remaining bulbs to their brightness before. Open the switch. Replace the bulb.

5. Reconnect the ammeter in series with one of the bulbs. Predict how the current will compare to the previous reading.

6. Test your prediction by closing the switch. Record the current and open the switch.

7. Remove a bulb in a different branch from the ammeter. Close the switch. Read and record the current value. Open the switch.

8. Connect a voltmeter across one socket. Close the switch. Read the meter, and record the voltage. Open the switch. Repeat for each of the other sockets.

References:

Modern Physics Holt: Rinehart and Winston (1990)
Physics: Principles and Problems (1982)

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Magnets, Electromagnets & Fields of Force

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Objectives:

Students will perform activities that enhance their understanding of the following:

*Magnets exist only as dipoles.
*A field of force exists around any magnet.
*Only items containing nickel or iron are attracted to magnets.
*Temporary magnetism can be induced by placing iron or nickel into a magnetic field.
*The movement of current through a wire is accompanied by a magnetic field.

Materials needed:

Enough good, strong pairs of magnets so that each person in class has a pair.

A paper/plastic plate and a ZipLok bag large enough to enclose the plate for each member of the class.

A quantity of powdered iron/iron filling.

Enough wire (16 to 22 gauge enameled) so that each member of the class has about 3 meters.

Enough (steel) nails (16 penny sinkers or larger) so that each member of the class has one and a similar sized non-ferrous nail or rod: use aluminum, brass, plastic,copper, wood (even a pencil).

Enough dry cells (11/2 volt C, D, or "ignition") so that each member of the class has one.

Sandpaper, for removing insulating coating from wire.

A large quantity of very small nails (brads).

Optional Power supply with output 12volt@>4amps, approximately 10m wire coiled into loop of about 10cm, neodynium magnets (approx. 2cm^2 by 1/4cm thick), compasses (of the type used in orienteering)

Strategy:

Dipoles & Fields

1. Encourage students to test the repulsion/attraction of magnets. How does the magnet's orientation effect this phenomenon? How can we label the ends of our magnet?

2. Line up magnets in such a way, or on such a device that they will pivot easily. What does moving one do to others? Do magnets have to touch each other to interact?

3. Will magnets stand on thin edge more easily if they are aligned to Earth's poles? Why?

4. Give students plate/bag with iron powder inside. Touch magnet to outside of bag. What happens? Does the way that magnet contacts bag/plate effect the iron fillings?

5. Hold plate parallel to ground, with iron powder in a compact heap. Hold

magnet against plate. Slowly tilt plate so powder runs toward spot above magnet in a sheet-like flow. What happens? What sort of pattern results? Draw it!

6. Repeat the above step holding the magnet against the plate in a different way-- if it was perpendicular before try parallel or vice verse. Try to make a map of the three dimensional field by adding these two-dimensional sets of information.

Electromagnets & Magnetic Metals

1. Begin by having students wind (coil) about half of their allotted wire around their steel nail. Expose the bare copper by sanding off coating. Contact the two free ends to the two terminals of the dry cell. How many nails can you pick up with this electromagnet?

2. Coil the rest of the wire onto the nail. Does the winding direction matter? Test the number of nails picked up.

3. How does the wire feel when it is hooked-up to the dry cell? Does using the electromagnet deplete the battery rapidly or slowly? Why? How might this be improved on?

4. Hold the electromagnet near the "ZipLok Field Mapper". Map the field!

5. Slip the coil off the nail. Try to do this while the electromagnet is connected. What happens to the strength of the magnetic field? Verify your results by using the "Field Mapper".

6. Slide a different material into the coil. What happens? Repeat with metals and non-metals. Does it matter if the metal is a poor conductor or good conductor? How can you explain this? Does it matter if the metal is hollow or solid?

Optional

Really cool demonstration from the Oersted Experiment.
Place a really strong magnet in or near the 10cm loop of 10m of wire. Turn on the power supply for a **very** short period of time (doing otherwise might short your power supply or burn up the wire). You've built a very crude solenoid. Try reversing the polarity. Try changing the position of the magnet. Try mapping the field. See what happens with a compass, or a whole bunch of compasses arranged around the coil (or inside it). What does this tell you about the operation of an electromagnet? What does this suggest about the role of the nail in an electromagnet?

Performance Assessment:

The best proof of learning is in the production of something useful. The goal is to build the strongest electromagnet you can. First plan out what materials you need and how you will connect/build your electromagnet. Creative solutions are appreciated, but consider how each element of your design contributes to the goal. This is called design efficiency, use it! In order to minimize the variables leading to success, a regulated 11/2 volt power supply should be substituted for dry cells. Similarly a pan of nails that is not susceptible to tampering is preferred over paperclips, which students may link into chains. Other means to ensure fairness should be discussed before the competition, as students are badly discouraged when they perceive someone cheated to win. If the rules are "anything goes" be prepared to require students to supply their own materials and set some spending limit (verified by receipts and/or catalog prices) that cannot be exceeded. Efforts to instill fairness in competition pay off with students working harder on the thinking and designing and caring less about the legality or the "the winner".

Conclusions:

The idea that the flow of an electric current is accompanied by a magnetic field revolutionized scientific understanding and has made possible most of modern life. The generation of electricity would not be possible without knowledge of this. Similarly all electric motors operate by taking advantage of this. The fame Ampere holds is directly traceable to Oersted's disclosure of his work at the September 1820 meeting of the Acadmie Royale des Sciences in Paris. The cooperative nature of science is clearly illustrated, as is the relative recency of the discovery.

Evaluation:

Students should answer the questions presented in the strategies. If their understanding is correct they should receive credit for this. If their understanding is lacking they should engage in more activities and this additional work should be acknowledged. Students who do not work and/or do not understand will harm themselves and the advancement of humanity.

References:

R.S. Kirby et al, **Engineering in History**. New York, McGraw-Hill.
R.A.R. Tricker, **Early Electrodynamics: The First Law of Circulation.** Pergamon Press.
William Gilbert, **de Magnete.** London, Royal Academy of Science.
J. Czerwiec, **Early Understanding of The Natural Philosophers.** Unpublished

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How Smart Are You About Electricity, Batteries And Conductors?

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Objectives:

Students will:

- identify a battery and how it works.
- identify how a flashlight works.
- understand the relationship between a battery and electrons.
- conduct a test to determine what materials are the best conductors.

(This unit will take two to three weeks) Grades 3-8

Materials:

Overhead projector and transparencies of all activities.
Activity 1. pennies and dimes or aluminum foil, paper towels, water, salt, vinegar, lemon juice and an ammeter
Activity 2. signs and small pieces of colored paper
Activity 3. D-batteries, 1.5 V bulb, masking tape, wire, aluminum foil and materials for decorating
Activity 4. batteries (1.5 or 6 V), bulb (1.5 or 6 V), wood(2 by 6 ins.), 4 feet of insulated copper wire (2 feet for each side), two pencils with eraser tips, two clean head thumbtacks, and a number of objects to be tested

Strategy:

Activity 1: MAKE A BATTERY

Students will identify a battery and how it works.
Teacher will demonstrate how to make a "VOLTAIC PILE" (named after the inventor of the battery).
Students will fold some paper towels about 1 inch square, soak them in one of the solutions with a 1.5 glass of water, by placing a dime, foil and penny on each side of the moistened towel, making a single cell, then connect your cell with wire on both ends of coins to ammeter. Students will notice needle moving thus indicating that there is a flow of current.
Next, students will make more cells piles, connecting them together to see how great the voltage will become. Students will record data as they add cells and take piles apart when finished so coins will not corrode.

Activity 2: **GAME**: PATH OF ELECTRONS

Students will stand in a circle to show how electrons work in a battery called a circuit, (a drawing of a battery showing the path electrons flow). At the top of the circle, one student will be marked negative (-), another will be the positive (+) end of the battery. A third student will be the switch, another one the bulb, and the rest of the students will be the conductors. They will have pieces of paper marked electrons. Students will start passing the pieces of paper around as shown on drawing. When the switch goes out of the circle, the light will go out. (This will show the current of electrons flow around and around the circuit as long as the switch is on. When the switch goes off, the current stop and the flow of electrons will stop and the light bulb will stop glowing.)

Activity 3: MAKING A FLASHLIGHT

Students will make a flashlight to see the relationship between a battery and conductors. Each students will be given materials needed to make a flashlight. First, cut tubes length-wise to fit batteries, then cut a piece of wire (strip bare the insulation), the wire should also be cut longer than the tubes. Make sure wire is connected to the battery and the bulb. Then use the aluminum foil as a conductor. If all connections are correct, current is complete and the bulb will light up. Students can decorate flashlight any way they choose.

Activity 4: CONDUCTIVITY TESTING

Students will construct a conductivity tester. They will learn how to connect one of the terminals of the battery to the bulb assembly (a flashlight bulb in a socket mounted on a piece of wood). One wire from the battery terminal and the other wire to the bulb assembly are to be connected to become the test probes. Wrap the wire around two clean-head thumbtacks (six times). Push them firmly into the erasers of the two pencils. When you apply testing probes to each object, the bulb will light up to show you that all metal objects are conductors of electricity. The bulb will not light up if objects are not good conductors. Students will make a chart to list and show good, poor and non conducting objects. Then list each object on different color pie-shaped papers. Mount them on a wheel to visualize the percentage for each category.

References:

Graf, Rudolf F., **Safe and Simple Electrical Experiment**
Strongin, Herb, **Science On A Shoestring**
Introduction to Physical Science: Addison-Wesley (1988).

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Introduction to Elementary Circuits

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Objectives:

1. Children should be able to predict ways to light a bulb.

2. Children should be able to define parts of an electrical circuit.

3. Construct and test models of electrical circuits.

Vocabulary:

1. electrons 2. positive and negative charge 3. conductor 4. energy
5. generator 6. convert 7. circuit 8. mechanical energy 9. battery
10. chemical energy

Vocabulary in Spanish:

1. electron 2. positive et negative charge 3. conductor 4. energia
5. generador 6. convert 7. circuito 8. energia mecanical 9. batera
10. energia quimica

Materials:

1. batteries, D cell 2. bulbs, #48 3. bare copper wire (activity 1)
2. batteries, IS6 cell 2. bulb, #48 3. copper wire 4. switch (activity 2)

Instructional Prompting:

Stimulate discussion by holding up the materials to be used and asking the students to name and describe the function of each. (If students do not supply the information, make sure that these ideas are covered: a battery is the source of electrical energy; the wire provides an unbroken pathway for the activated electrons from the battery to energize the copper electrons in the copper wire. The bulb is placed in the path of the electron flow thus converting this energy into light energy.

Ask the students to predict how they could arrange the materials to light the bulb. Write several of their predictions on the board and discuss the principles of circuits and whether or not their predictions meet the criteria.

Students will now be given the materials for activity 1. After each attempt a drawing of their attempted circuit should be made. This procedure will continue for 15-20 minutes or until the students have perfected their technique of lighting the bulb.

At this point, explain to the students that they have made a circuit with the materials. Review the parts of the circuits, review the criteria of a circuit then have volunteers draw on the chalkboard arrangements that made the bulb light. Stimulate discussion by asking, "What are the three parts of the circuit?" (a source of electricity, a bulb, and a wire); "In what path did the electricity go to make the bulb light?" (It made a complete path or circle from the energy source, to the bulb, and back to the energy source.); "What happened when the path or the circle was broken?" Have the students trace the path of electricity in their circuits when the bulb was on.

After thorough discussion of the simple circuit, the concept of a switch is introduced as a controlled break in a circuit. This switch is constructed with a small (2in x 3in) poster board sheet, a paper clip, and two brass paper fasteners. The switch must be connected between the (-) term. of the battery and the (+) term., with two copper wires connected to the (in) and (out) of the switch. The (in) wire of the bulb was connected to the (out) of the switch, the (out) wire of the bulb was then connected to the positive term. of the source.

Performance Assessment:

1. Request that all children name the three components of a simple circuit.

2. Request that all children, while looking at their materials, name and draw each function in a circuit of the materials they have in front of them.

3. While examining their drawings or reattempting activity 1, have children diagnose the problems with the circuit prior to the successful lighting of the bulb.

Rubric:

3 pts-If students can I.D. all necessary components of a circuit, successfully light the bulb in the circuit and successfully connect a switch to the circuit.
2 pts-If students can I.D. all necessary components of a circuit, successfully light a #48 bulb in the circuit.
1 pt--If students can I.D. all necessary components of a circuit.

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Electricity

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Objectives:

To explain how objects can receive a static electrical charge.
To describe the effects of bringing objects with like and unlike charges near one another.
To compare conductors and insulators.
To identify and diagram a series circuit and a parallel circuit.
To explain the function of a fuse.

Materials:

T.V. set, string, chalk, balloons, wool cloth, thread, chalkboard, water sprayer, size D batteries, battery clips and holders, small bulbs (#41 & #48), sockets for small bulbs, copper wire, objects to test as conductors, paper clips, plasticine, and strands of steel wool.

Strategy:

1. The students will perform the following activities to understand how objects receive a static electrical charge: Let the string hang about one inch from the front of the T.V. set. When the television is turned on, the string will be repelled or attracted to the television screen. Students will inflate several balloons. They will rub the balloons with a wool cloth to create an electrically charged surface. These balloons will cling to the classroom ceiling and to a chalk drawing of a shelf on the chalkboard.
2. The students will perform the following activities to understand the effects of bringing objects with like and unlike charges near one another: Students will inflate two balloons to the same size and tie a string to each balloon. Both balloons will be given negative charges by rubbing them with a wool cloth. They will repel one another. Next, one of the balloons will be given a positive charge. This balloon will be attracted to the negatively charged balloon. The balloons will be sprayed with water to neutralize them.
3. The students will perform the following activities to compare conductors and insulators: Using a simple series circuit with one small bulb, each student will test objects to observe which materials permit a flow of electrons (conductors) and which materials do not permit a flow of electrons (insulators). Each student will list items tested and test results on a chart.
4. The students will perform the following activities to understand series and parallel circuits: After learning how to read a circuit diagram, each student will construct a series circuit and a parallel circuit. The students will make observations about what happens when one bulb is removed from each of the different types of circuits. They will also observe which circuits have brighter bulbs.
5. The students will perform the following activities to understand the function of a fuse: Using uncomplicated written directions, each student will make a fuse. The students will observe what happens to a fuse when too

much electricity flows through the wires.

Performance Assessment:

1. Using a diagram and sentences, explain how lightning is a form of static electricity.
2. What type of circuits are used in buildings? Explain.
3. Describe a safety device that is used as part of a circuit. Explain how it works.

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Magnets, Electromagnets, and Motors

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Objectives:

1. Students will understand the general properties of magnets.
2. Students will understand and make an electromagnet.
3. Students will use electromagnets to do work, and they will make an electric motor.

Materials Needed:

Materials needed are listed with the strategy to which they apply.

Strategy:

A. **Exploratory (Give as homework the day before the lesson.)**

Each student is given two magnets and is told to take them home and explore the properties of magnets, making as many observations as he/she can. The guide sheet below might be helpful to direct them.

MAGNETIC PROPERTIES: An Attractive Assignment

1. Do the magnets attract all objects?
2. List 10 objects that are affected by the magnets. Do they have anything in common?
3. List 10 objects upon which the magnet has no effect? Do these objects have anything in common?
4. What might affect the ability of a magnet to attract another object? List as many factors as you can.
5. Is there a limit to the number of things that can be attracted to the magnet at one time? Test this.
6. Try and locate magnets in your house. Do these magnet show the same qualities as the ones above?

DON'T FORGET TO BRING YOUR MAGNETS BACK TO CLASS!!!

B. **Concept development - "A Magnetic Discussion"**

1. List the following on the overhead for students to answer while you check their homework. MAGNETIC OR NOT (Don't list answers, just items)

REFRIGERATOR DOOR	**YES**Students are familiar with this.
SOFA	**NO** Students may argue a sleeper sofa has metal, but most textiles, wood, and foam insulation are not magnetic.
COKE CAN (OR 7UP)	**YES**These are made of steel.
PEPSI CAN	**NO** These are made of aluminum.
DOLLAR BILL	**YES**The ink has a little bit of iron in it, so that pop and candy machines can tell if its the real thing and not a photocopy.
CEREAL	**NO** HOWEVER, cereals claim to be iron fortified, and in some cereals, if a magnet is dropped into the box, it can be recovered from the bottom of the box with iron filings stuck to it. Iron fortified??

2. Go over the above list and include in your discussion student

observations of things that were magnetic in their home. Give as many students as possible a chance to answer. Lead into the properties of magnets..."Let's organize all this information."

3. PROPERTIES OF MAGNETS (list these on the board)
   1. Attract many, but not all metals. (Iron, nickel = magnetic) (Note demos below)
   2. Exert a force at a distance. (Magnets don't have to touch an object to move it. Use the overhead projector to show a magnet pushing another one along, etc.)
   3. Attract or repel another object. Magnets have direction!! Show this by placing two magnets on the overhead; if they attract initially, flip one over--now they should repel. (N vs. S) A COMPASS is an instrument used to detect magnetic fields; the needle is magnetic and therefore is sensitive to other magnets. **LAB 1:** Map the forces or field lines around and/or between two magnets. Trace the magnet(s), and use the compass to determine the direction of the magnetic field.
   4. Can make another object magnetic. (Magnetic Induction) Show this using a magnet and two iron nails. First, show that the two nails aren't magnetic. Then magnetize one nail by touching it to a magnet. Touch the second nail to the first. Observe that they hang together. (Paper clips work well for this too.) Follow-up questions could be the following: Is there a limit to how much you could pick up? Why? What observations support your thinking?
   5. PERMANENT vs. TEMPORARY magnet
      Ask: What would happen if we took the magnet with two nails hanging from it and carefully removed the magnet? (Get Hypotheses) Carefully remove the magnet. The nails retain their magnetism for a short time. These are TEMPORARY magnets. Permanent magnets will stay magnetic forever unless something disrupts their chemistry.

THE DOMAIN THEORY

The atomic structure ultimately determines whether an object is magnetic or not. The Domain theory says that areas of atoms within an object exhibit magnetism. However if these areas are scattered, then they cancel each other out and the object is non-magnetic. If they are lined up in a parallel fashion, all facing the same direction, then the object is magnetic. (This is easily seen by drawing a picture....unfortunately no graphics allowed here.) To check for student understanding, ask the following question: Why did the nail from above become magnetic? Why did it lose its magnetism?

C. **Electromagnets: Turning a magnet "on" and "off"**
1. Permanent magnet--no "on" and "off", always "on"
2. Induced/Temporary magnet--not always reliable, when will it go off?
3. Electromagnet--Turn current on, and magnetic field is on. Current off and magnetic field is off.

What is an electromagnet? A moving electron (current) generates a magnetic field around the wire. Demo: Hook a wire up to a battery; a compass placed nearby will be deflected. Disconnect battery and compass deflects back to rest.

Why/How is this useful? Many items use this principle: power locks in cars, electric staplers, furnace relays, for example. The most familiar example is the junkyard magnet that picks up cars and drops them on top of a stack.

LAB 2: Making a Junkyard Electromagnet

Each group is given some wire, different core materials (nails), a power supply (batteries), and ten-fifteen minutes to experiment and build an electromagnet. The group that picks up the most "paperclip cars" wins. Award magnets as prizes.

D. **Motors...**

If we combine all of our knowledge so far (review the main ideas again), and go one step further, we can begin to understand and even build an electric motor.

1. Electric motors use current to set up two magnetic fields.
2. These fields are set at right angles to each other.
3. By turning a field on and off (alternating current), we cause little pushes against the other magnetic field. This allows us to do work; the flywheel of the motor spins, etc. Demo: a free spinning magnet at rest can be set in motion by bringing a magnet close to it.

LAB 3: Building a Motor

Using the kit provided, follow the instructions, and build the motor. (I usually give students two days or a weekend) Kits are from a catalog.

Performance Assessment:

Question: You are stranded on a desert island and have been captured by some potentially hostile natives. All you have in you pocket are four fairly strong magnets and some string. You must "wow" the natives in two different ways to save your life, what will you do?

Rubric:

5 points: The person designed a compass, taught the natives how to use it, left the island, and navigated back to civilization. Then sold the magnets and began a new life.
4 points: The person clearly stated two different ideas and convinced you as a native that they understand magnetism.
3 points: The person has two ideas, but not clearly stated. You aren't completely convinced or "wow"-ed.
2 points: The person has only stated one idea, or has two ideas that lack explanation. This answer is poorly stated and incomplete.
0 points: The person threw the magnets at the natives and ran the other way.

Multicultural Emphasis:

Dans la langue de votre choix, vous pouvez enseigner cette lesson. Suivez le planning precedent. Donnez-moi un coup de telphone si vous avez besoin de la vocabulaire.

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Magnets

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Objectives:

To experience another kind of force (beside gravity or electric charge ...) which is always present and affecting us: magnetism.
To explain how magnets, magnetic poles and magnetic fields are related.
To formulate the force law for magnets: ($F = \frac{k\,mm'}{r^2}$)

Materials:

Bar and cow magnets, magnetic compasses, rulers, cereals and papers

Strategy:

Activity 1. Grind the cereal into very fine pieces. Use the cow magnet to attract iron from the cereal.

Activity 2. On the projector, show the two poles of two magnets and how they attract or repel each other.

Activity 3. Break a bar magnet into two halves. Turn a half magnet around on the projector to show they repel each other; magnetic poles always occur in pairs on each magnet. (Otherwise the north half and the south half poles should always be attracted.)

Activity 4. Place a bar magnet on a large piece of paper. Place a compass near the north of the magnet. When the needle comes to rest, make a dot or an arrow on the paper to mark the direction in which the north pole of the compass needle is pointing. Move the compass until the south pole of the needle points to the mark. When the needle is again at rest, make another dot to mark again the direction. Repeat this procedure and connect the points by a smooth curve. Repeat the procedure to draw a few field lines on each side of the magnet. Notice that each line begins at the north pole of the magnet and ends at the south pole. Do any of the field lines cross? The rate at which the needle quivers as it comes to a stop is proportional to the field strength. FOR THE TEACHER: On the projector, cover a bar magnet with a transparency. Sprinkle some iron filings on the transparency while gently tapping it. Compare the pattern made by the filings and the field lines.

Activity 5. Place a magnetic compass on the middle of a metric ruler so that the north and south of the needle is perpendicular to the ruler. Place a bar magnet on each side of the compass on the ruler with the south-seeking poles of the magnets pointing toward the compass. When the compass needle stops at the old position again (pointing north), compare the distances from the compass to the two magnets. If the distances are the same, then the magnets have the same strengths (m=m'). If not, the north-seeking compass needle points toward the stronger magnet (m not = m'). Move the stronger magnet along the ruler until the forces of the magnets balance. The ratio of the square of the distances is proportional to the strength of the poles.

Activity 6. Place two magnets on the overhead. Use Newton's Third Law to "show" that the magnets pull (or push) equally on each other. Therefore, the force must be proportional to each magnet's strength (m, m'). Show that the pull or push (F) is larger when the distance (r) between the magnets is less, thus the force (F) is inversely proportional to the distance (r). It is not obvious that the force is inversely proportional to the **square** of the distance , but the similarity to the Gravitational Force (F_g) and the Electric Force (F_e) should lead to acceptance of the square of the distance between the magnets in the formula:

$$F = \frac{k\,mm'}{r^2}$$

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Exploring Series and Parallel Circuits

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Objectives:

1. To arrange batteries, bulbs and wires into functioning series and parallel circuits.
2. To represent simple circuits using schematic diagrams.
3. To explain and compare the effects of series and parallel circuits on bulb brightness, relating the phenomena to the potential differences, current, and resistances throughout the respective circuits.

Materials needed:

for each group of 2-4 students:
- 2 size-D dry cells (batteries)
- 6 pieces of bare copper wire
- 3 flashlight bulbs
- 3 bulb holders
- 1 multi-meter

for demonstration purposes:
- one large scale series circuit
- one large scale parallel circuit
- light bulbs of various wattages
- (optional: logic circuit)

Strategy:

1. Try to arrange one bulb (without holder), one battery and wire in as many ways as possible to make the bulb emit light. Sketch each arrangement, including failures as well as successes. Similarities among the successful trials should be discussed.

   >In order for the light bulbs to light, there must be direct connections from one battery terminal to the metal side of the bulb and from the metal bottom of the bulb to the other terminal. Review the concepts of potential difference, current and resistance. Introduce a "circuit" as a complete path along which a charge can flow from the negative terminal of a power source to the positive terminal of the source. Electrons flow continuously in a closed circuit.

2. Repeat step 1 with the bulb placed inside a holder. Have the students note which two parts of the bulb the holder makes contact with.

   >Contact is made with the metal side and the metal bottom of the bulb.

3. Using one battery, light as many bulbs in as many holders as possible. Sketch each arrangement, noting the ones that work. Compare results among the different student groups.

   >Ask the students which arrangements made the most bulbs glow. When more than one bulb is introduced into a circuit, the possible arrangements include both series and parallel circuits as well as various combinations of the two. The parallel arrangements should make the most bulbs glow. Introduce schematic diagramming (using symbols to represent electric

circuits) for wires, batteries and resistances.

4. [Series] Wire two circuits in series. One should have one bulb, while the other should have two bulbs in series. Do the bulbs light in each of these series circuits? Compare brightness.

   >The circuit with two bulbs should be less bright.

5. In the circuit with two bulbs, unscrew one of the bulbs. Note what happens to the other bulb.

   >The other bulb goes out.

6. [Parallel] Set up a parallel circuit with two bulbs. Do both bulbs light in this parallel circuit?

   >Both bulbs should light.

7. Unscrew one of the bulbs in the parallel circuit. Note what happens to the other bulb.

   >The other bulb should remain lit. Have the students describe in their own words the differences between series and parallel circuits. Guide them in making a descriptive list of the two types of circuits on the chalkboard. Use larger scaled series and parallel circuits with larger light bulbs as part of a demonstration to help develop the concepts. Have multi-meters available to test the current, potential difference and resistance at various points along each circuit.

Series Circuits

>A single path is allowed for electron flow.
>A break anywhere along the path stops the electron flow in the entire circuit. (Devices in series act dependently.)
>The total resistance in a circuit is equal to the sum of the individual resistances along the current path. $R_T = R_1 + R_2 + R_3$ ...
>The current anywhere along the circuit is equal to the voltage supplied by the source divided by the total resistance of the circuit. (Ohm's Law)
>The potential difference, or voltage, is decreased over each resistance. The sum of the "voltage drops" should be equal to the amount of voltage supplied. $V_T = V_1 + V_2 + V_3 + \ldots$
>The voltage drop across each device is proportional to its resistance.

Parallel Circuits

>Branches are formed providing separate paths for the flow of electrons.
>Since current branches into separate pathways, a break in one or more of those pathways does not interrupt the flow in the other paths. (Devices act independently.)
>The total equivalent resistance is less than the value of any individual resistor. $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$
>Each device connects the same two points of the circuit; therefore, the voltage is the same across each device.
>The amount of current in each branch is inversely proportional to the resistance of the branch.
>The total current is equal to the sum of the currents in each branch.

$$I_T = I_1 + I_2 + I_3 + ...$$

References:

Hewitt, Paul, **Conceptual Physics**, Addison-Wesley, Menlo Park, CA, 1987

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Magnets

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Objectives:

1. Discover how magnets work.
2. Demonstrate magnetic lines of force.
3. Find materials that can be attracted to magnets.

Materials:

Magnets (disk, bar, horseshoe), nails, corks, erasers, paper clips, coins, cloth, wires, foil, paper, sticks, iron filings, compass, thread, tape, pins, plastic, salt, wax paper, pan, pendulum, metal sheet, bottles and container.

Strategy:

1. Demonstrate to the class some magnet tricks.

Trick #1. Floating Disk. Put two rings on the pencil so that the rings repel each other. Hold the bottom ring and move it up and down along the pencil. What did you find out? Try the trick with a stick, too. The upper ring will jump up and down as if it were attached to a spring. The force of magnetic repulsion will keep the top magnet in the air. Students may try this trick by pairs in their seats.

Trick #2. Rolling Rings. Hold one ring between your thumb and forefinger in a vertical position. Hang the second ring on the first ring edge to edge. With a slight movement of your hand you can make the second ring travel round and round the first ring.

Trick #3. Stand up nine nails on their heads in three rows of three nails about one half inch apart. Use horseshoe magnets to remove each nail one at a time without disturbing any other nails. If another nail falls or moves, it is your friend's turn.

Trick #4. Hanging Pendulum. Tie a length of thread to two small disk magnets. Tie the other end of the thread to the pendulum so that the magnets hang about three fourths of an inch from the metal sheet. Arrange several pieces of magnets on the metal sheet. Swing the pendulum and feel the magnetic lines of force. What happens?

Trick #5. Bearded Man. Put about three pinches of iron filings on a picture. Slide a horseshoe or bar magnet underneath the picture. Arrange the filing units into hair, eyebrows, moustache or beard. The iron filings will stand or move. Return the iron filings carefully to the bottle container.

Trick #6. Mix a half teaspoonful of sugar with the same quantity of iron filings in a bottle. Ask the audience how to separate them. As you move the magnet around the bottle, the iron filings will follow but the sugar will be left behind. Repeat the experiment with a salt mixture, water and glue.

Trick #7. Put two bar magnets side by side so that north and north pole are facing each other. What happens? Repeat the procedure by putting north and south pole facing each other. Now what happens to the magnets?

Trick #8. Put iron filings in a small glass pop bottle. Using a testtube, glue it on the inside of the top. Put a cow magnet inside the tube. Shake the bottle and the filings will stand up and form a pattern showing the magnetic lines of force.

2. Predict which objects will be attracted to a magnet. Touch your bar or horseshoe magnets to each of the items. Which are attracted by and stick to the magnet? Which are not attracted? Record the results on the chart by checking yes or no next to each item listed. Decide with your group what kind of material each item is made of.

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Electron Current Flow

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Objectives:

The student will understand how and why electric current passes through a conductor due to a potential difference.

The student will discover the proportional relationship between voltage and resistance and their effect on the measurement of current flow.

The student will discover that, with a constant voltage, the smaller the diameter of a conductor, the smaller the current flow.

Materials needed:

Five-gallon bucket with globe valve attached to the bottom outside rim, 3/4 x 18 CPVC pipe w/screw adapter, 1/2 x 18 CPVC pipe w/3/4 screw adapter, 1/4 x 18 potable water line epoxied to a 3/4 screw adapter, U-tube constructed from 2 12-oz plastic pop bottles glued into 2 3/4 CPVC 90º ells connected with an 18" length of 3/4 CPVC pipe, a 10-foot ladder, enough 3/4 CPVC pipe and couplings to attach the bucket suspended on the ladder to pipe lengths on the tabletop, a stop watch and a 3-liter pop bottle (graduated).

Strategy:

Working on the principle that water and electricity flow with similar characteristics, a discussion of electric current flow is conducted making analogies to the flow of water. In the U-tube, using water dyed blue with food coloring, the fact is explained that water does not move unless additional water is poured into one side causing a difference in potential. This causes movement in the water until potential equilibrium is reached.

Explaining that an excess of electrons at one end of a conductor causes an electrical potential difference, electrons will similarly flow until electrical equilibrium is reached. How much flows (introduce the term, current) depends on the potential difference or pressure (introduce the term, voltage) and the opposition to flow (introduce the term, resistance).

Using the bucket of water at tabletop height with the three different sizes of pipe connected to 3/4 screw adapters, measure the volume of water which flows through each pipe in ten seconds using the graduated 3-liter pop bottle. One student uses the stop watch, another measures the volume and a third keeps a chart of the results on the chalk board.

It can be seen now that if voltage is constant, a smaller pipe (conductor), carries a smaller current. Now the formula, $E = I \times R$, is placed on the chalk board. The students discuss the relationships of the values and are asked to derive the equation, $I = E / R$. We have seen that if resistance is high (the smaller conductor), current is low and that, conversely, small resistance (the larger conductor), transports a larger current. At this time the quantities are introduced for measuring volts, ohms and amperes.

The students are asked, "Looking at the formula how else can we increase the current besides decreasing the resistance?" A student will answer, "By increasing the voltage." At this time the bucket can be placed on the shelf of the 10-foot ladder. The extra 3/4 CPVC pipe and connectors are used to extend the water supply to the tabletop where the pipes were before. Again, three students, a timer, a measurer and a recorder, chart the volume of water from each pipe in ten seconds. More water will come out across the chart because the pressure of the water is increased. Its potential difference is increased. The students, therefore, find that increasing the voltage also increases the current.

If time permits, actual values for voltage and resistance can be supplied and the value for current can be calculated mathematically or this can be begun on the following class meeting.

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Conductors and Insulators

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Objectives:

1. To provide an understanding of basic electrical terms.

2. To compare the electric current flow in conductors and insulators.

3. To teach the operations of a series circuit by designing a quiz board.

Materials:

(For each group of four)

wood
rubber
glass
paper clips
1.5 volt dry cell
cardboard
aluminum foil
plastic
12 volt automotive bulbs
sockets
electrical wire
piezo buzzers
battery holders
nails
coins
paper

Recommended Strategy:

(Teacher Preparation)
Prepare four series circuit units for testing materials. Each unit will consist of a light or buzzer connected to a battery and placed on a wooden board for support.

All materials will be separated into five stations on laboratory desks. Students will be divided into groups.

Activity 1

Students will test 10 different objects to determine if they are conductors or insulators. All data should be recorded.

Activity 2

Construction of quiz board.

Remove the insulation from 4 pieces of electrical wire for about 1 inch on both ends. Wrap several turns of one end around a paper clip. Wrap the other end around a second paper clip. Repeat process until you have four wires with paper clips at each end. Place a 1.5 volt battery into holder. Connect piezo buzzer to the battery. Prepare questions and answers for quiz board. The correct pairs have to correspond to your wiring. Arrange the wiring on the quiz board to conform to it. Whenever a question is answered correctly, by placing the wire from the buzzer to paper clip next to the question and a second wire from buzzer to the paper clip next to the answer, the circuit will be completed and the buzzer will sound. Students will return to seats. A question and answer period will follow.

Results:

After we connect a wire between the terminals of an electric cell, we find that there is an electric current in the wire. A wire that will carry or conduct an electric current is called a conductor. In order to have a current, there must be a complete circuit of conductors, a path that the electrons can follow back to their starting point. Insulators are materials that cannot easily conduct an electric current.

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OHM'S LAW

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Objectives

(a) to become aware of Ohm's Law, the relationship between current, voltage, and resistance in a series circuit

(b) to solve selected problems using Ohm's Law

Equipment and Materials

Garden hose with nozzle; circuit board or plywood; 3 - 1.5 Volt DC batteries; 6 battery clips & 3 battery holders (not needed if hobby batteries are used); 2- 4.5 V bulbs; l variable resistor (the one used was 25 Ohms 2 Watts); bell wire; screw driver; 2 lamp sockets; multimeter (optional).

Recommended Strategies

1. Review basic laws of electrostatics and conductivity. Also, review schematic diagrams of simple circuits.

2. Use the garden hose to demonstrate the analogy of water pressure with voltage, drops of water with electrons, flow of water with electrical current, resistance of hose and nozzle with resistance in a circuit etc.. During discussion, introduce key vocabulary terms: AMPERE; VOLTS; OHMS; RESISTANCE; CURRENT

3. Connect one, then two, and finally three 1.5 volt dry cells in a series circuit to a socket with a 4.5 volt bulb. The pupils will observe and explain the varying degree of brightness of the bulb with respect to the increased voltage and the increased current.

4. Connect 3 - 1.5 volt dry cells in series to both sockets, using 4.5 volt bulbs. The pupils will notice the bulbs' brightness as compared to using one or two dry cells. The pupils will explain.

5. Insert the variable resistor into the circuit [You will have to connect the negative terminal to the center terminal with a clip], using 3 dry cells to one socket with a 4.5 volt bulb. The pupils will vary the resistance from the least resistance to where the bulb will not light. The pupils will observe and explain.

6. Through discussion, the class will realize the relationship between current, voltage, and resistance (Noting that this is for D.C. current only).

7. Introduce the pupils to **OHM'S LAW : CURRENT =** VOLTAGE

RESISTANCE

VOLTAGE = CURRENT X RESISTANCE **RESISTANCE =** $\frac{\text{VOLTAGE}}{\textbf{CURRENT}}$

Current is measured in Amperes; Voltage is measured in Volts; Resistance is measured in Ohms.

8. If available, use a multimeter to measure the current and voltage in the circuit, then calculate the resistance. Now, measure the resistance and compare to the calculated value.

9. Pupils will use math skills to solve selected problems using **Ohm's Law**

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Electric Currents and Circuits

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Objectives

1) To create an awareness of the importance of electricity in everyday life.
2) To introduce basic electrical terms and to illustrate how electricity moves, both in series and parallel circuits.
3) To show the need for a complete electric circuit, how to control electron flow with a switch and to teach series and parallel circuits.
4) Students should be able to wire dry cells either in series or in parallel when given several dry cells, pieces of wire and bulbs.

Equipment and Materials

ammeter	hand crank generator
voltmeter	Christmas tree lights
insulated copper wire	Manila folders
1.5 - volt dry cells	1.5 - volt light bulbs and sockets
foil	brass fasteners or paper clips

Recommended Strategy

Have materials displayed on table or desks. (make sure there is an obvious display of examples of series or parallel circuits, such as Christmas tree lights)

Review the part/importance of electricity in everyday life

Discuss and review the vocabulary you will be using

circuit	volt	voltmeter
current	dry cell	ammeter
series	resistance	terminal
parallel	conductor	ampere
ohm	watt	fuse

Have students divide into groups in order that they may work cooperatively with each set of materials.

a. The first activity should be a simple bulb, battery, and foil assembly. The object of this activity is to reinforce the understanding of what is necessary for a circuit to be completed. A worksheet should accompany the set-up.

b. The second activity will be a human circuit - students holding hands and then touching the generator

c. The third activity will enable each group to devise its own circuits through the use of provided panels and materials. By the process of trial and error along with previous knowledge the students should be able to trace both types of circuits.

A culminating activity will be for the students to begin a take home project which is a question/answer game circuit board.

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Magnetism

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Objectives:

After completing this project, students should be able to:

1. Name two properties shared by all magnets.
2. State what will happen to a magnet that is suspended so that it is free to turn in any direction.
3. Describe how one magnet will affect another magnet when the poles of the magnets are arranged in a certain way.
4. Tell how a piece of iron can be made slightly magnetic.
5. Use your Magnetic Crane to explore magnetism.

Apparatus needed:

1 battery (9 volt)
1 battery snap with leads
1 nail
plastic coated wire (26 in.)
1 rectangular block of wood (4 in. x 1 3/4 in.)
1 angled block of wood (4 in. x 1 3/4 in.)
1 spring clothespin
2 each small screws and nuts
electrical tape
glue
scissors
a ruler
pliers
magnets
iron

Recommended Strategy:

Magnetic Crane Procedure:

1) Glue the angled block to the rectangular block so that it angles out over the edge. Set aside to dry.
2) Put the small screws through the holes in the clothespin so that the heads are on the inside. The heads should touch each other when the clothespin is squeezed.
3) Leaving about three inches of wire at the end, wind the plastic coated wire neatly around the nail starting at the head and winding down. Do not overlap the wire as you wind.

4) Wind the metal end of one of the leads from the battery snap (either one) around the bare metal end of the shorter (3in.) length of wire from the nail. Secure this with about 2 inches of electrical tape so that it does not slip off.
5) Connect the other lead from the battery snap to one screw on the clothespin and secure it there with a nut. Connect the bare metal end of the long piece of wire from the nail to the other screw and secure it with a nut. You may need pliers to bend the wire.
6) Attach the battery cap to the battery.
7) Tape the wires along the blocks so that the nail hangs over the angled block. Tape the battery to the crane so that the snaps face the center.
8) Place the clothespin switch on the back of the crane so that the screws hang over the end of the block. Tape the bottom half of the clothespin to the block.
9) To make your magnetic crane work, press the clothespin switch so that the screw heads touch. As long as you hold the switch closed the nail will attract small metal objects.

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What Is Electricity

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Objectives:

To develop an understanding of the fundamentals of static electricity, namely that of materials, conditions, and charge. To learn how to detect a charge by the use of electroscopes. To learn how to determine the force between charges.

Materials

Demonstration Van de Graaf generator, Jacobs ladder, thread, aluminum foil, long plastic tubes (golf club protectors), cat or rabbits fur, ebonite rods, glass rods, ring stands, silk pieces, scissors.

Strategy:

This lesson is usually scheduled as the first in a series at the beginning of the second semester. In fact, the concepts given today are usually spread over three to five class periods. The equipment is set up before class time. Then some time is spent checking to see if it is working properly. One must work very carefully with the Jacob's ladder coil because its output can be deadly, therefore extreme caution must be practiced. It has also been suggested that a clear plastic shield should enclose the apparatus for safety purposes. The lesson starts with the question, "What is electricity?". The student's response gives one six or seven ideas which are written on the blackboard and then are emphasized with the demonstrations. After these are completed the students are divided into groups due to lack of equipment and are pre-instructed how to rotate from station to station doing all three parts of the lesson which consisted of detection of charge, making an electroscope, and determining the amount of force produced by the charge on an object. At least three trials are to be used on the force part and or using different materials to familiarize the student with the workings of Coulomb's Law. After the groups have been finished, the class as a whole will discuss the concepts and develop a consensus for their lab reports to be turned in a few days later.

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The Millikan L'Eggs Experiment

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Objective:

To use discrete masses to simulate the Millikan experiment (the discrete charge on the electron).

Apparatus:

one balance per group and EITHER
a large number of L'Eggs eggs (from panty-hose) individually numbered and filled with ball bearings or clay such that the filler is divided into 'unit masses' i.e. for a ball bearing filler, use multiples of 7 bearings (or some multiple larger than the weight of the 'shell'). It is nice to have several regular intervals and then skip one (put in two additional unit masses)
OR
10 numbered plastic Easter eggs filled with clay or bearings (as with the L'Eggs eggs) for each group

Strategy:

Present the problem of how to find the mass of a unit 'yoke' where there is a shell and **at least** one 'yoke' in each egg. If the students cannot come up with the idea to mass them on a balance, suggest it. After they have massed their eggs, some may see a pattern but suggest that they draw a histogram of their data (mass vs. number of eggs with that mass (NOT egg number)). It should be obvious from the graph that the masses fall into several groups. From the average mass of each group, students should be able to see that the groups fall at regular intervals and that these intervals correspond to each additional unit mass (one more 'yoke').

Discussion:

A discussion should be held to talk about the number of digits of accuracy needed in the measurements since the shells and unit masses will each vary by some small amount. It is possible for the students to become so involved with making accurate measurements that they miss the pattern or waste too much time on the weighing.

After the experiment is done, a comparison should be made between this experiment and Millikan's oil drop experiment where he found the unit charge of the electron by looking for regular intervals (or discrete units of charge).

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Electrochemistry

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Objectives:

One form of energy may be transformed into another. How can electricity be changed into chemical energy? How can chemical energy be transformed into electricity?

Apparatus needed:

Strips of copper, zinc, lead, magnesium
0.5 M solutions of soluble salts of copper, zinc, lead and magnesium (acetates or chlorides)
0.05 M copper (II) sulfate
plastic cups (preferably clear)
index cards (support strips)
voltmeters (milliammeters, galvanometers as available)
insulated wires
one lemon

Recommended strategy:

I. Changing electricity into chemical energy
   A. electrolysis of water
   B. electrolysis of saturated sodium chloride solution
   C. electroplating

II. Changing Chemical energy into electricity
   A. A zinc strip is put into a 0.5 M solution of copper(II) sulfate and allowed to stand for at least two hours. Another cup of the same solution without the zinc strip should be prepared at the same time for comparison. Record observations. Write equation. A reaction has occurred spontaneously with the liberation of a small amount of heat energy. Could that energy be harnessed in the form of electricity?
   B. Stick strips of copper and zinc into a lemon and connect to a meter. Is electricity being generated?
   C. Moisten a small piece of paper towel in your mouth and put it between a penny and a dime. Touch the penny to one lead to the meter and the other lead to the dime. Is electricity being generated? This is a Voltaic cell.
   D. In order to cause electrons to pass through an external circuit instead of reacting directly with the liberation of heat energy, the two electrodes must be separated. However the electrons must have a pathway or the circuit will not be

complete. This can be accomplished with a semipermeable membrane or a salt bridge. The salt bridge can be a U shaped glass tube filled with a conducting solution, but we will use a strip of porous paper which has been dampened with a saturated solution of sodium or potassium chloride.

Fill one cup with the solution of zinc acetate and mount a strip of zinc metal through a slit in an index card in this solution. Fill another cup with a solution of copper acetate and mount a strip of copper metal in this cup. Stand the two cups side by side and hang a damp strip of paper over the sides so that one end is in the zinc acetate solution and the other end is in the copper(II) acetate solution. Now connect the two electrodes by copper wires to the meter. Does the meter give evidence that an electric current is generated? Record whatever quantity and units the meter shows.

Repeat, using all the possible combinations of the four metals. Note which metal is at the positive electrode. Does current flow if the metals are reversed. Twelve observations.

-	+Cu	Pb	Mg	Zn
Cu	XX			
Pb		XX		
Mg			XX	
Zn				XX

Write equations:

Can we rank the metals in order activity? Arrange on a line.

III. Standard Reduction Potentials - The potential difference across a Voltaic cell is easily measured, but it is impossible to measure an individual electrode potential. Therefore the hydrogen electrode which consists of a platinum electrode immersed in a 1.0 M solution of hydrogen ions is assigned a value of zero and all other half cells are measured with respect to this. Here are some standard reduction potentials:

$Cu \longrightarrow Cu^{+2} + 2e$ -0.337 v

$Pb \longrightarrow Pb^{+2} + 2e$ 0.126 v

$Mg \longrightarrow Mg^{+2} + 2e$ 2.370 v

$Zn \longrightarrow Zn^{+2} + 2e$ 0.763 v

Oxidation potential equals reduction potential with the sign changed. The predicted potential difference is the algebraic sum of the oxidation and reduction potentials.

Example: Zn + Cu = 0.763 -(-0.337) = +1.10 v

The observed voltage is always less than the predicted voltage. Calculate the predicted voltage for each of these cells, having first written the equation and identified the element which is oxidized. How do these values compare with differences taken from the number line above?

IV. Discuss drawings of:

A. Flash light dry cell
B. Alkaline dry cell
C. Automobile battery

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Electric and Magnetic Fields

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Objectives:

To introduce the concepts of MAGNETIC AND ELECTRIC FIELDS to the students via the use of phenomenas as magnetism and electric current flows.

Apparatus needed:

Large magnets(2), Nails, Metal rings, Several Coils of wire, Van De Graff generator, Ping-Pong Ball, Fishing line, Several metal objects.

Recommended strategy:

Set up a stand that has several nails that are attached to the table (tape them if possible).Above the nails place one of the large magnet at distance that will cause the nails to appear to float in air.At this point a discussion is held concerning the set up. Several pieces of materials can be placed in the space between the magnets and the nails to illustrate the their effects on the magnetic field, this should enhance the discussion of the properties of the magnetic field as most objects other than thick metal plates have little or no affect on the floating nails.

The Van De Graff generator can be used to demonstrate the electric field. Suspend a ping-pong ball above the table (use a ring stand if necessary) that has been coated with a metallic paint. The space around the ball is normal before introducing the Van De Graff into space near the ping-pong ball(make sure that the ball can't touch the Van De Graff if swong in that direction). When the generator is turned on the ping-pong ball should swing close to the generator. A discussion should start concerning the space around the ball and generator. Afterwards a small fluorescent tube can be placed in the space near the generator in way that both ends of the tube are the same distance from the generator's surface (creating an equipotential along the tube). Now the tube should be turned slowly in a manner to place one end of the tube close to the generator and the other away from it. The effect of the light glowing should be food for considerable discussion about Electric fields and fields potentials.

Using some clear plastic and wire (heavy gauge) an overhead projection device can be constructed to illustrate the connection between electric and magnetic fields. The plastic should be cut in the shape of a rectangle and a small hole should be drilled in the center of the plastic about the size the of a 12 gauge wire. Then place a strip of wire through the hole in the plastic so that it is perpendicular to the flat surface of the plastics sheet.

```
                                        I-----0
                         WIRE ---->     I
                                        I
                           _____________I __________________
                          /             I                  /
       PLASTIC -------> /                                /
                       /________________________________/
                                        I
                                        I
                                0-------I
```

The two ends of the wire should be attached to a circuit that contains a six volt motorcycle battery and a knife switch hooked - up in series. Now iron fillings should be liberally spread around the plastic sheet. When the switch is closed circles should form around the wire. It may help to tap the plastic sheet gently to help see the lines of force form. These lines are due to the magnetic field made by the current in the wire. This should provide food for much discussion about electric currents and their associated magnetic fields.

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Current-Carrying Coils In Magnetic Fields

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Objectives:

At the end of this exercise the student should be able to:

1. predict the direction of movement for the pointer of a home-made galvanometer for a given current direction.

2. describe how the current-carrying coil exerts a force on the magnet.

3. predict how the number of turns of wire in the rotating coil influences the rotation speed of the motor.

4. describe why the DC motor works without an armature.

Apparatus needed:

1.5 m of enameled copper wire, one 1.5 V battery, one film cannister, two paper clips, 4 large rubber bands, one flat magnet with a hole, one hair pin, two nails, one small piece of wood or pegboard, two alligator clips, one large plastic bag

Recommended strategy:

Each student takes a plastic bag with apparatus inside. Teacher asks "How can this 'junk' be used to find out how a current-carrying coil is influenced by a magnetic field?" After a short discussion, the teacher shows models of film-cannister galvanometers and DC motors. Students are encouraged to construct their own models and try to discover:

How does the number of turns of wire on the loop or galvanometer change the behavior of the apparatus?

Does the distance of the rotating coil to the magnet influence the speed of the coil?

Does the number of batteries change the speed?

How does the direction of current through the coil influence the direction that the galvanometer swings?

The direction that the motor coil rotates?

Explain how the coil exerts a force on the moving magnet in the galvanometer.

What makes and breaks the circuit in the DC motor if there is no armature?

Reference:
"The Electric Motor Challenge", Physics Teacher. March, l74 (1985).
"Improvement on the Electric Motor", Physics Teacher. May, 308 (1985).

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Coulomb's Law

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Objectives:

Observe qualitatively the relationship between electrical charge and force.

Determine experimentally the quantitative relationship between force and the center to center distance between charged objects.

Experience reinforcement of the above concepts through preferred perceptual modes (tactile, kinesthetic, auditory, or visual) through appropriate activities.

Materials:

Van der Graff generator, ring stand, coffee can, styrofoam cups, string, rubber tipped dart, paper and plastic sheets (optional), overhead projector, file folders, graphite coated pith or styrofoam balls, nylon stranded string, masking tape, centimeter or other grid on overhead transparency, plastic sticks, wood blocks, oak tag board, markers, coat hangers, ruler, index cards, transparent tape, large (approximately 8m*.5m) sheet craft or butcher paper, rubber and glass rods, silk cloth, piece of fur, electrophorus.

Procedure:

1. Set up the Van der Graff, in line with a veriac if the generator does not have a variable control, with the coffee can inverted over the top of the ring stand in such a way that, when the generator is turned on, a clearly visible spark jumps from the generator to the coffee can. Have the students observe the spark and the noise produced and describe what they see. Draw the connection with lightning and be sure the students understand that the light and noise which they saw and heard were due to electrical charge. **Run the generator at a MUCH SLOWER SPEED** and have the students note the sensation the generator produces when they hold their arms close to it.

2. Attach the broad end of a rubber tipped dart to the top of the generator with a piece of string tied around the opposite end of the dart. The other end of the string should be taped to the outside bottom of a styrofoam cup. The cup should then be inverted over the upper end of the dart attached to the generator. When the generator is turned on at high speed the cup will be repelled from the end of the dart and will be held in mid-air by the charges on it and on the generator. Remind the students of Newton's first law. Since the cup was moved from a state of rest by the charge produced by the generator clearly a force was produced by the charge. More examples can be given of the same phenomenon using pieces of paper, plastic, fur or other material. The students should now be able to make a qualitative statement that charged objects produce a force on one another.

3. The quantitative aspects of this activity are available in several published sources. Two which are useful are "Coulomb's Law,"**Laboratory Physics**, James T.Murphy and Judith L.Doyle,Charles E. Merrill,1986.,and "Coulomb's Law on the Overhead Projector," J.B. Johnston,**The Physics Teacher**(January,1979).

4.Several activities can be devised to reinforce the main concepts of this lesson and others related to them. Such activities are by no means limited to the following suggestions.

Kinesthetic activity: Winther's Linear Accelerator: Using a 7.5m *.5m sheet of craft paper, butcher paper or plastic divide the sheet into fifteen equal squares. Label the center square "start" and number out in both directions to seven. Pick five students who are kinesthetic learners. One student is the

operator. The other four are divided into two teams of two. Each team has either 2
positive or negative charges. The operator gives each player in turn a card which tells that player how to move. The team which is the first to have a player to exit the accelerator is the winner. The instruction cards read, "move one space left," "move one space right," "move one space closer to an opposite charge," and "move one space further away from a like charge." This will reinforce for these kinesthetic learners the concept that like charges repel and unlike charges attract . The number and content of the cards may be varied depending on the group using them.

Tactile/Visual Activity: Learning Circle: A learning circle can be constructed out of oak tag board. Cut two circles from the board of the same size approximately 18" in diameter. Divide each circle into eight equal wedge shaped sections. Attach the two circles to each other with a coat hanger sandwiched between them in such a way that they can be hung up. The faces of the circles which have been divided into sections should be aligned with each other, facing outward. In each section of one circle put a a statement from the chapter summary with a key word or phrase omitted. Attach each of the omitted words or phrases to a cloths pin so that the students can attach the word or phrase to the appropriate section of the circle to make a completed statement. The back of the cloths pins and the sections on the back of the learning circle may be coded to facilitate checking the answers of the students after they have matched the words and phrases with the appropriate statements. As either in-class or homework activities students can construct their own learning circles using one the teacher or other students made as a model. This activity serves as reinforcement for tactile/visual students. Puzzles or electro-boards serve the same purpose.

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Mathematics/Physics

Sound: The Vibration of Materials

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Objective(s):

1. Students will recognize that sound is produced by the vibration of materials. 2. Students will recognize that the sound produced is dependent on the type of material that is used. 3. Given four types of material; air, string, wood, and metal, students will identify air as being the poorest conductor of vibrations, and metal as being the best. 4. Students will recognize that if there is no material to vibrate there will be no sound. These activities are suitable for students in the primary grades.

Materials:

rulers	Tubes	Ticking objects	3 ft. cotton string	3 yds. Thin wire	Vacuum jar
	Rubber bands	1 ft wooden rod	3 ft. thin wire	3 yds. Cotton string	Ticking object
	Thin rubber sheets	1 ft. metal rod	Metal spoon	Cups-paper or styrofoam	
	Paper clips				

Strategy:

1. Hold the ruler 4 inches over the edge of the desk. Strike it. Observe its movement and listen for its sound. What kind of movement did the free end of the ruler make? What did you hear?

2. Stretch a thin sheet of rubber over each end of the tube. Secure each end with a rubber band. Thump one end of the tube while gently holding your hand over the other end. Feel and observe. What do you feel? What do you hear? Now place a paper clip on the rubber sheeting at one end of the tube. Thump the rubber sheeting at the other end. What do you see? What do you hear?
3. Get 3 ft. of cotton string. Tie the spoon at the center of the string. Wind about 3 inches of string around the forefinger of each hand. Stick those fingers into your ears and strike the desk with the spoon. Observe. What do you hear? Follow the same procedure using 3 ft. of wire. Observe. What did you hear? Compare the two sounds.
4. Get a wind up clock or a timer. Press one end of the wooden rod against your ear; place the other end against the ticking object. Observe. What did you hear? Follow the same procedure using the metal rod. Compare the two sounds.
5. Get 3 yds. of string and two paper cups. Place a small hole in the bottom of each cup. Place each end of the string through the hole in the cup and secure the string by knotting it. With a friend, stretch the string. One person whispers into the end of the cup. The other person places the other cup to the ear and listens. Observe . Follow the same procedure using 3 ft. of thin wire. Observe. Compare the two sounds.
6. Place a ringing alarm clock inside of a vacuum jar. Ask the class what they think will happen when the air is removed from the jar. (The sound of the ringing should fade into silence or close to silence as the air in the jar is removed.)

Performance Assessment:

After students complete activity #1, they should be able to state that they observed the rapid up and down movement of the ruler and that while the up and down movement was taking place sound could be heard.

After students complete activity #2, they should be able to state that they heard a sound when the sheet of rubber was thumped, that they felt movement at the opposite end of the tube, and that the paper clip bounced when they thumped the opposite end of the tube.

After students complete activities #3,4,5, they should hear sounds through the wood, wire, and the string. They should observe the difference in sounds when they are transmitted through the various materials.

After the students observe activity #6, they should be able to state that the reason the sound in the jar is getting softer is because the air in the jar that is being reduced. When all of the air is removed from the jar the students should not be able to hear the ringing. There is no air in the jar for the alarm clock to vibrate and so there is no sound being heard.

Grading Rubric:

A - Student will be able to state that sound is produced because some material is vibrating. Student will be able to demonstrate vibration by doing activities one and two which involve either seeing or feeling the vibrations. Student will conduct activities 3,4, and 5 to demonstrate and explain that the sound which is produced depends on the material through which the vibration occurs. Student will be able to predict that as the air in the vacuum jar is removed the ringing will get softer.

B - Student will be able to state that sound is produced because some material is vibrating. Student will be able to demonstrate vibration by doing activities one and two. Student will be able to demonstrate that the sound produced depends on the material being vibrated by doing two of the following three activities (activities 3,4, or 5). Student will be able to predict that as the air in the vacuum jar is removed the ringing will get softer.

C - Student will be able to state that sound is produced because some material is vibrating. Student should be able to demonstrate vibration by doing activity one or two. Student will be able demonstrate that the sound produced depends on the material being vibrated by doing at least one of the following activities (activities 3,4,5). Student will predict that the sound in the vacuum jar will get softer.

D - Student will be able to state that sound is produced because some material is vibrating. Student will be able to demonstrate vibration by doing activity one. Student will be able to demonstrate that the sound produced depends on the material being vibrated by doing one of the following activities (activities 3,4,5). Student will observe that the sound in the vacuum

jar is getting softer.

Conclusions:

-

Sound is produced when materials vibrate.

The type of sound produced depends on the material through which the vibration occurs.

There can be no sound if there is no material to vibrate.

References:

Physics, VanCleave, Janice. John Wiley & Sons, 1991.

Sounds Experiments, Broekel, Ray, Children's Press, 1983.

Primarily Physics, Hillen Judith, et.al., AIMS, 1990.

Juliette M. Walker - Crown Community Academy

Now Hear This!

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Objective(s):

In this project, students will be able to describe how sounds are heard by the human ear by creating a model of the human inner ear. This activity may be utilized by grades 3 - 8.

Materials Needed:

Students may be placed into cooperative learning groups of 3.
1long paper roll (used gift wrap rolls are perfect)
plastic wrap   medium sized disc of foil   rubber bands
2cardboard paper discs   doublestick tape   pink tissue paper
flashlights   1 large box   scissors   cardboard fork shape
(1 set of each item is needed for each group)

Strategy:

1. Students will create an eardrum by stretching a piece of plastic wrap across the end of the paper roll fixing it in place with a rubber band.
2. Students will create a set of ossicles with two cardboard discs and a fork shape of thin cardboard. This will be held together with doublesided tape.
3. Students will then attach a disk of shiny foil to one end of the roll, and will attach the other to the plastic wrap "ear drum" on the tube. This will complete the middle ear.
4. Students will then make an outer ear from a cone of cardboard with a hole at its end and will place it on the inside of the tube. Students may design their cone with pink tissue paper, for a more realistic look.
5. Students will then place the middle of the model of the ear on a box, leaving the ends of the rolls hanging off of the front and back.
6. Students will then shine a light onto the mirror and will ask a partner to to talk into the ear and watch for vibrations.
7. Have the students to watch the window of the ear. Have them describe how it responds to shouting, whispering, whistling etc.

Performance Assessment:

Students will be evaluated based upon their models, and oral explanations as to how their ear works.

Conclusions:

This project works because the sound waves from the students voice makes the plastic wrap vibrate. These vibrations are transmitted into the cardboard "ossicles" and can be seen by watching the foil disc for movements. This is a simple model of how the ear works.

References:

This project was adapted from the **Encyclopedia of Science Projects** written by Pam Robeson, and Mick Seller (Shooting Star Press, 1994) (Aladdin Books, ltd, 1994)

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Cheryl Pitts - Crown Academy

Let There be Light

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Objective(s):

The students will learn the process of photosynthesis.
This is for all grades. The level can be scaled according to the level of the students.

Materials Needed:

1. shallow trays or containers (the number needed for your class size)
2. potting soil
3. watercress seeds
4. water
5. cardboard (larger than the tray)
6. stencils (letters and fun designs)
7. SUNLIGHT!!!

Strategy:

1. Fill shallow tray/container half full with potting soil. Scatter watercress seeds freely covering the entire tray/container. Moisten the tray with water.

2. Cut initials and/or design from cardboard, place it over the seedlings. Make sure the sunlight cannot reach the plants beneath. * The cardboard should be a little bit larger than the tray/container except for the cutout areas itself.

3. Leave the tray in a sunny position. Keep the soil moist while the watercress is growing. Wait for approximately two weeks for the plant to germinate and grow.

4. During this growing process do not remove the cardboard. You should occasionally turn the tray/container to allow equal amounts of sunlight parts of the tray.

5. When you observe that the watercress is fully grown, remove the cardboard. You will be able to see your initials or design in the pattern of growth. At this time the watercress leaves will be much darker green than the rest of the plant.

Performance Assessment:

The evaluation will be primarily based on students' observations and data recording of the growth of the plants.

Conclusions:

Because the process of phototropism, the plants will grow toward the light. Hence, the plants will grow through the openings in the stencil and create a pattern.

References:

Encyclopedia of Science Projects Shooting Star Press, 1994

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Pamela Lopez - Betsy Ross Elementary School

Mixing Primary Colors

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Objectives:

The kindergarten students will be able use different ways to mix primary colors. There will be two activities for mixing primary colors.

1. Rainbow Squeeze
2. Color Blends

Materials Needed:

Activity 1 "Gelatin Squeeze"

1. unflavored gelatin
2. water
3. food coloring
4. zip lock bags
5. tablespoons

Strategy:

Preparation
"Rainbow Squeeze"

Pour 2 cups of cold water in to a quart measuring cup. Sprinkle 3 envelopes of unflavored gelatin over the water. Let stand for 1 minute. Then add 2 cups of boiling water. Mix well with a tablespoon. Divide the mixture equally into 3 bowls. Add several drops of blue food coloring to one bowl, yellow food coloring to the second bowl, red food color to the third bowl. Mix well with a spoon. Chill overnight. Remove to room temperature.

Procedure

1. We put the rainbow squeeze into bags.
2. We push out the air, seal the bags.
3. Then we squeeze the bags.
   What colors did we make?

To the tune of "Mary Had A Little Lamb"

1. Mixing paints is lots of fun, lots of fun, lots of fun. Blue and yellow, paints make green. Try and you will see.
2. Purple comes from red and blue, mix them well, mix them well. Red and yellow will make orange. Try and you will see.

Performance Assessment:

The children will have fun feeling the cool gelatin as the colors are being blended together.

Preparation
"Color Blends"

Materials:

1. red, yellow and blue Tempra Paints
2. paint brush
3. 3 cups for each color of paint
4. 1 cup of cold water
5. white construction paper
6. geometric shapes

Procedure

1. Draw shapes to overlap each other to fill the entire piece of paper.
2. Paint one end of a shape. Add the second color to the first, little by little. Fill more of the shape. Each time you will begin to see the color blend.
3. Paint another shape with a different color. Add the second color, continue this procedure from step (2).
   Fill in the entire picture.

Colors To Mix

1. red+blue = purple
2. red+yellow = orange
3. blue+yellow = green

Now you have mixed primary colors to make secondary colors.

Conclusions:

Activity 1- Children will be able to see how the gelatin colors mixed.
Children will be able to demonstrate this activity at home.

Activity 2- Children will review shapes and colors before doing this activity.
Children will have fun tracing shapes and blending colors.

References:

1. Teacher Edition "Silver Burdett"
2. "Starting To Paint"

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Biology/Chemistry

Light and Vision

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Objectives:

Explain Normal Eye

Define Refractive Error terms

Explain Refractive Errors

Demonstrate Refractive Corrections

Materials Needed:

The following materials are sufficient for a class of twenty.

1. 10 shoe boxes
2. 10 flashlights
3. 10 glass or plastic jars
4. 10 glass or plastic jars
5. 10 scalpels
6. 1 gallon various liquids (for example, water or vegetable oil)
7. 10 pencils
8. 20 eye diagrams

Strategy:

Introduction:

The teacher will demonstrate the construction of a shoe box experiment. To construct the shoe box experiment you would use the scalpel to cut two slits into the end of the box; the slits must be close enough for the light source to cover. Once this is done you would than place a jar of water or liquid in front of the light source.

Steps 1 through 5 (Construction of Shoebox Model)

- Draw two lines, two centimeters apart on one end of the shoebox
- Cut a narrow slit along each line
- Put the sheet of white paper in the bottom of the box
- Carefully put the jar full of water in the box. Make sure you line the jar up with two slits
- In a darkened room, shine the flashlight through the two slits. See how the jar of water or oil bends the light. You may need to move the jar to make the rays meet.

Performance Assessment:

Students will be assessed in the following:

- Identify the refractive error based on the location of liquid in the jar and its distance from the light source in the shoebox
- Write and/or verbally explain the following terms: myopia (nearsightedness), hypermetropia (farsightedness), and astigmatism (imperfect vision or image)
- Explain individually and cooperative groups how light affects vision
- Demonstration how refractive light can cause an astigmatism

References:

Ardley, Neil **The Science Book of Light,** Harcourt Brace Javanovich Pulbishers, 1991. Orlando, Florida.

Polarization of Light

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Objectives:

This lesson is most appropriate for high school, but could be revised with a little thought and effort for lower grades.

Students will discover that polarization filters will be able to block incoming light from passing through when filters are positioned perpendicularly to each other.

Students will be able to explain why the filters block some of the incoming light and also redirects incoming light.

Students will be able to explain some of the uses of polarization filters within our society.

Materials Needed:

3 polarization filters, about 1.5 inches by 1.5 inches, per student
3 wood gates that will simulate polarization filters
Several small layered pieces of cheap transparent tape, per student
One transparent protractor
One pair of polarized sunglasses
Small sandwich baggie for students filters and tape swatch
Length of surgical tubing
note: polarization filter sheets, 1 square foot, can be purchased at the American Science and Surplus for $7.50 and then cut with sturdy scissors

Strategy:

Pass out one baggie with the three filters and swatch of transparent tape layerings to each student. Tell the students to take out two filters and play with them for a while. After some time several students should discover that when you hold them on top of each other and rotated just right that you can't see through the overlapped area. Have those students explain how to do this with the filters and allow everyone to do the same. Why does this happen?

Most light travels in waves that comes towards us vertically, horizontally, and at all other angles of tilt. With this illustration on the board, hold one wooden fence vertically in front of your picture and ask what direction will pass through the screen. Hold the same fence horizontal and ask what direction of light would pass through this fence. Hold the fence at an angle that matches one of your illustrated angled light rays. Which direction light would pass through this filter? We're driving home the idea that the fence only allows the same direction light through it that the fences slats are held. This is a concrete example of the polarization filter and light rays.

Send a vertical wave with the tubing through one fence that is held vertically, the wave can get through the fence. Send the vertical wave through two vertical fences, the wave can get through. Send a vertical wave through the first fence which is vertical, and the try to turn the second fence horizontal. Did the wave get through any of the fences, both of the fences, why? We're trying to explain why the filters blocked the light when they were turned just right, perpendicular to each other.

Students should now experiment with the three filters and see if they can discover that if the middle is at a 45 degree angle to the bottom, and the top is perpendicular to the bottom filter that will either give you a hole in the middle of your sheet, or an "unhole" in your blacked out background. The angeled filter redirects the vertical or horizontal light a small amount, thus allowing some of the light from the second filter to pass through the third filter. This can be illustrated by holding the three fences up in front of themselves and taking it step by step with the students.

Place the transparent tape swatch between the two filters. Students should notice different colors of light in the tape depending upon the thickness of the tape. The tape can also be layered on a small piece of cut glass. They could even make their own art projects from this. Placing the clear protractor in place of the tape gives a similar appearance. The dark bands of light represent where the plastic met when the protractor was poured in the mold. These are the relief spots, or points of weakest strength. Engineers can do the same by surrounding parts with transparent plastic and viewing the test pieces under stress through polarization filters. Note: the tape is birefringent, meaning certain colors of light pass through it at different speeds separating out the colors of light.

Have the students find surfaces in the room that reflect light with a glare. Now view the glare through one of their filters while rotating it at different angles of rotation. They should discover that reflected glares are eliminated with a polarization filter. The reflected "glare" light is polarized the same direction as the reflecting surface. Ex: horizontal desktop...horizontally polarized light, vertical watch face...vertically polarized light. Ask students when they normally encounter light that reflects in a glared fashion, and if they normally like looking at this glared light.

Place one filter in front of sunglasses lens, test to see if sunglasses are polarized. Now test a pair of polarizing sunglasses. Hey, just like when they had two polarization filters.

Optional: Take one filter outside on a sunny day and view the sky, not the sun, through the filter. Is the sunlight slightly polarized? It should be somewhat polarized depending upon the weather for the day.

Big Hint: Illustrate your ideas with the filters on an overhead projector so everyone can see what you are doing. Be careful not to melt the filters on the screen and to not tell them what to do with the filters, let them do the discovering and experience the phenomena for themselves.

Performance Assessment:

What direction would the polarizers be in a pair of polarizing sunglasses if you used them while driving your car or fishing on a lake?

References:

Conceptual Physics by Paul Hewitt

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Light

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Objectives:

Lesson for K-4th grade (depends on how you modify them)
(1) Learning about light.

(2) What kind of property does light have?

(3) How light travels in a straight line?

(4) How light can be reflected.

(5) How light can be absorbed.

(6) How light can be refracted.

(7) Light is energy.

Materials Needed:

two mirrors, two volunteers, light source

Strategy:

(1) Each of the volunteers will pick up a mirror.
(2) One of them will go out and stand by the outside door so that he/she can use the natural light as light source. The other person will stay inside the auditorium in a way that both of you can see each other.
(3) Turn off the light in the auditorium.
(4) The person outside will hold the mirror up to make a light beam so that the light beam will hit right on the person who is holding a mirror inside the auditorium.
(5) The person inside will hold the mirror up so that his/her mirror can use the light beam which comes from outside to make another light beam and hit the screen inside the auditorium.

BONUS ACTIVITIES - How to make a Kaleidoscope?

Materials:

a paper towel roll, a 6-foot by 10-foot wrapping paper,
3 pieces of glasses of same size, scotch tape, a cap for the roll
clear plastic paper, two rubber band, drill

Strategy:

(1) Use the three piece of glasses to form an equilateral triangular prism.
(2) Use the hot glue gun to stick them in place.
(3) Pick up the prism and put it inside the paper towel roll.
(4) Use the wrapping paper to wrap around the paper towel roll with the prism inside and tape it.
(5) Put a piece of the plastic paper on each end of the paper towel roll and have each of them stay in place with a rubber bend.
(6) Drill a hole on the cap.
(7) Put the cap on one end of the roll.

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Mixing Colors With Light Beams

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Objectives:

The objective of this lesson is for pre-schoolers and primary graders to learn about mixing colors by light beams. The enjoyment of seeing the colors change and learning the difference from mixing paints.

Materials Needed:

These materials are for the teacher to give the lesson.

Three Projectors or some source of light to project the different colors of mylar paper
A color template
Three pieces of mylar paper, green, blue and red
Three small or medium size mirrors
An overhead projector

Strategy:

To begin this lesson the teacher is to give a homework assignment the night before. The homework assignment is for the children to go home and look at their color television screen. While looking at the T.V. move very close to it and see what colors they see.

When they return the next morning, you ask who did their homework. Those children are to tell you what colors they saw. The teacher then explains that they are going to mix colors of light today.

You begin by placing your three color template on the overhead projector. Turn the overhead projector on, then turn it around so the light beams are toward the back of the class. Now you will ask three students to help find the light beams with the mirrors. When they find them, ask that they put them on the front wall or screen if you have one. Now you ask them "If you mix red and blue together what will you get?", they will say purple. Then you ask the children who have red and blue to put their light beams together. Then ask "What if green and red were mixed together, what color would you get?" As you ask the questions you are mixing the lightbeams. Give the children a chance to try to mix them on their own and take turns. You are also to mix all colors together in different ways.

RED and GREEN MAKE YELLOW
BLUE and RED MAKE PURPLE
BLUE and GREEN MAKE BLUE-GREEN OR AQUA
RED, BLUE and GREEN MAKE WHITE **YES WHITE**

Discuss colors, color mixing by addition is the mixing of light of different frequencies.

Performance Assessment:

I have made this simple for primary children. They will enjoy seeing the lights and colors. This lesson can be used for upper grades if you add a more difficult task. You can also have the children work with paints and learn the difference by working with different colors.

Conclusions:

1. The amazement of this lesson is due to the way the human eye works.
2. Note, the primary colors of light are different than the primary colors of paint.

References:

Ms. Ann Brandon, my mentor in S.M.I.L.E. Physics

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Sound

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Objectives:

To demonstrate different ways to produce sound.

Strategy:

Ask students to think of any way they can to make sound. Write it down on the board and then try to categorize it. Students may be confused in the beginning, but they should have a better understanding after they have gone through the activities.

Activity #1

Materials:

a clothes hanger, a 15-foot thin rope

Strategy:

(1) Have a volunteer tie the rope to the hook of the hanger.
(2) Pull the rope hard to ensure the knot is secured.
(3) The volunteer will hold the end of the rope, wraped around his/her hand two times, and walk to an open area.
(4) He/she will then start swinging the hanger in the air. People around should be able to hear the sound being produced by the hanger.

Discussion:
Ask who can tell what made up the sound. The answer may vary, but basically the sound is being produced by the vibration of the hanger through the air. (This is a simulation of string instrument.)

Activity #2

Materials:

two wooden blocks with handles

Strategy:

(1) Have a volunteer hold the blocks by the handle.
(2) Hit the blocks together to produce certain kind rhythm.

Discussion:
Explain to students the method just demonstrated to produce sound is called percussion. Ask them if they can think of a similar way to produce sound.

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Polarized Light

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Objective:

This mini-teach was created with high school students in mind but can work with grades as low as maybe 4th or 5th grade. The idea is to show what polarized light is and show some examples and applications from the "real world".

Materials Needed:

*Each student receives 2 square pieces of polarizing sheet, 2-3 inches on a side. They will also receive 1 smaller piece perhaps only 1 inch on a side. You'll also want enough material left over to make two larger filters (maybe 6 inches on a side) for your demo use on the overhead. This material is available from American Science Center, $7.50 for about a square foot. Two or three of these sheets is probably enough for a class set.
*A standard PSSC coil spring.
*You need to build 3 mini picket fences. 1x1 inch stock is fine. I built mine with 4 slats each about 3 feet high. The spacing of the slats should allow the passage of the coil spring with enough clearance to allow the spring to vibrate freely.
*Several rolls of cheap celophane tape. Try some different brands but usually if it has a yellowish tint to it it's the stuff you want.
*Plexiglass squares or glass squares approximately the same size as the student polarizers.

Strategy:

Pass out two polarizers to each student. Ask them to take a few minutes to observe light passing through the filters individually and in series. Suggest various orientations and let them "play for a few minutes". Ask them what they have observed and duplicate what they tell you on the overhead with your filters. Eventually you should get to the point where rotating one polarizer 90 degrees with respect to the other alternately turns the light on and off.

Now to the spring. Suspend one end of the spring in a clamp while you hold the other end suspended about 4 feet off the ground in front of the class. Send signals down the spring and review or discuss basic ideas of wave motion. Now pass the spring through one of your picket fences. Have a student hold the fence with the slats vertical. Now ask which kind of vibrations sent by you will be passed on by the fence, up and down or side to side. Do it! Now add a second student and a second fence. Arrange them so they are both vertical (the fences that is!). Note that the vertical vibrations that pass through the first fence also pass through the second fence. Now have the second student slowly turn his polarizer 90 degrees and note that the vertical vibrations from the first fence are now blocked by the second fence.

At this point, the students will hopefully see the connections between the demo with their polarizers and the spring and you can say, if you like, that a polarized wave is one that is only vibrating in one direction.

Question: What will happen if we put a third polarizer between two already crossed polarizers? Pass out another polarizer to each student but perhaps smaller than the original ones. Most will think that nothing will happen but if the middle one is at 45 degrees to the plane of polarization of the other two light will again get through. The students will eventually discover this and you can duplicate it on the overhead. This is curious. Now try to simulate this with your spring and fences. Have the two outer fences at right angles to each other and the middle one vertical. As you have a student rotate the middle fence 45 degrees you should once again get some waves through the third polarizer. The middle one re-steers the polarized wave to have vibrations somewhat in the direction that the last one will pass.

Give each student a piece of glass or plastic with one piece of celophane tape on it. Again ask the students to place the tape between crossed and uncrossed polarizers and try various orientations of the tape and polarizers. Give them a few minutes to play with this. You might ask along the way if the tape is just another polarizer and how can you tell if it is or not? You will find that the tape will redirect the polarized light similar to what the third polarizer did and yet the tape is NOT itself a polarizer. You can tell because you cannot turn the light on and off by using one known polarizer and one piece of tape.

(Note for the interested: the tape is birefringent. It has two indices of refraction depending on the direction of the vibrations and when you present polarized light at 45 degrees to these directions some of the wave goes down the "fast" axis while some goes down the "slow" axis. This can cause a twist in the direction of the polarization thus allowing the passage of light through the last polarizer.)

Now, either on the overhead or individually with the students or both, try making layers of tape and viewing light through various layers layed down parallel to each other. You should begin to see a color effect depending on how many layers. This tends to be "brand dependent" as to what color you get with how many layers. Try viewing the colors with the polarizers crossed and uncrossed. They change! Is there a rule for what colors change to what other colors?

Optional - Kyro syrup will also have this twisting effect and not unlike the tape the color you see when the syrup is between crossed polarizers depends on the depth of the syrup. You can compare containers of different depths of syrup. You'll need some sort of container with a flat clear bottom.

Many cheap plastic items such as protractors will show colors which indicate locations of stress when viewed between crossed polarizers. You can also try a piece of plastic such as from a zip lock bag. Hold it between crossed polarizers and slowly stretch it. You should see colors appear indicating locations of stress.

Note: Many of the things above require you to manipulate things between crossed polarizers. If you are one of those with only two hands you may want to put one polarizer on the overhead stage while you hang the other in front of the overhead lens. Watch out for heat on this one on some overheads.

Performance Assessment:

Ask the students to find a source of polarized light in the room and to explain how they know that this light is polarized. They may not say the light from one of the polarizers.

Many reflections off of non-conductors are partially polarized such as from a table top. You can prove that this light is polarized by looking at it through ONE polarizer and rotating it. If this light source gets dim and bright then you are in fact looking at polarized light.

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Sound

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Objectives:

This lesson was designed for grade K-3. The lesson will be taught over a period of three weeks.

The student will be able to identify and understand these vocabulary words: vibration, volume, pitch, particles, tuning forks, waves and matter.

The student will be able to understand that sound travels through gas, liquid and solid.

The student will be able to understand the idea of pitch, both high and low.

Materials Needed:

Tuning forks, balloons, styrofoam cups, string, 5 gal. can covered with rubber to make a drum, paper clips, stopwatches, glass bottles, spoon, straws, sentence strip paper, scotch tape, water, small teddy bear and pvc pipes.

Strategies:

1. I will model and introduce the lesson by showing the students the Teddy Bear, styrofoam cup and the five gallon can. (The can top is covered with rubber and a hole is in the bottom of it). I will ask students what will happen if I placed the cup on top of the Teddy Bear and turned the hole toward the cup and strike the drum can. We will discuss the effect. Allow students to experiment with striking the can.

2. **What is vibration**?
Display the vocabulary words. Each student will receive a balloon and the second person will receive a stopwatch. Explain. The students will blow up the balloon and knot it. Tell them to place the balloon close to their throats and hum. How does their throat feel? Tell them to experiment with all sorts of sounds on their throats.

Next they will with form partners. Explain how to use the tuning fork and the stop watch. They will observe how long their balloon vibrates and listen to the sound of the balloon vibrating. They will strike the tuning fork and touch the balloon. Discuss the results.

3. **Communication**
Review vocabulary words that we have identified so far. Introduce the other words through this activity. Ask students how they think sound travel through the telephone when they are talking. Discussion. Explain how they will make a telephone using two styrofoam cups, two paper clips, and string about two to three feet long. Each student will make a telephone following direction given by the teacher. They will work as partners. After they complete their phone allow time for communication and play. Discussion.

4. **Pitch**

Explain how a straw flute is used to determine the pitch of sound. Explain how to make a flute. Allow students to experiment after they have made their straw flute. Explain that the pitch of sound gets higher as the length of the flute decreases.

The "Singing Bottles". Explain how pitch is identified by using bottles. Experiment by adding different amounts of water to the bottles to make different sounds. Place the bottles in a row and gently tap the bottle with a spoon. Discuss how does adding water affect the sound made.

Performance Assessment:

All students will be able to identify high pitch or low pitch by performing on pvc pipes as instructed by the teacher.

All students will be able to identify how sound travels by experimenting with the styrofoam cup telephone.

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Color

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Objectives:

This Mini-Teach is designed for K-6. This lesson is designed to introduce primary and secondary colors of light.

Materials Needed:

Activity 1

Paper Plates
Scissors
Crayons
Pegs or Pencils
Rulers or Protractors
Tape

Activity 2

Red, blue, and green filters
Overhead Projector
Three Mirrors

Activity 3

Bubble Solution
Bubble Wands or drinking straws for each student

Activity 4

A Flag that has green and black strips, black stars, and a yellow background where the white is suppose to be.

Strategies:

Activity 1 (Circle Wheel)

With the scissors, cut the outer circle off of paper plate, divide the plate into eight equal sessions and color it red, blue, yellow, purple, white, green, indigo, and orange. Put a hole in the center of the circle, push the pencil or peg through the hole and attach the tape to back of plate. The purpose of the peg or pencil is to spin the plate.

Activity 2 (Color Demonstration)

The object to this activity is to show how the primary colors (red, blue, and green) are separate colors but if you mix these colors you make secondary colors. Then if you mix secondary colors you make white.

Activity 3 (Bubbles)

The students use the bubble to first blow and observe. The students are then asked to make a list of all colors that they observe in the bubbles. The students are then asked what kind of light they see hitting the bubbles. They should say they see white light passing through the bubbles causing the bubbles to appear different colors.

Activity 4 (Is Seeing Believing)

The students are given a flag that is black, green, and yellow. The students are then asked to stare at the star in the bottom right hand corner for 30 seconds and then turn the card over to the white side and observe what happens. The students should see the pinkish-red, white, and blue american flag. The colors appear because the eye cones get tied and see complementary colors of the original colors. Example: White light minus green gives pinkish-red, and White light minus yellow gives blue.

Performance Assessment:

The students are then asked to answer in written form "What happens when you add blue, yellow, green, and pink together?" They should answer White.

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Sound

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Objectives:

This lesson is designed for grade levels 1 - 3.
1. To understand that sound is caused by vibration.
2. To understand that sound travels through solids, liquids and gases.
3. To understand that high pitched sounds are caused by more vibrations and low pitched sounds are caused by fewer vibrations.

Materials Needed:

plastic ruler(s), tuning forks of 2 or 3 different pitches, ping-pong ball attached to a string with tape, boom-box-type radio, balloon filled with air, paper plate, tiny pieces of torn paper, baggie filled with water, scissors, several glass bottles of the same size, large container for water, styrofoam cups, wire coat hangers, string (different types), wire cutters, pencils (with wooden ball attached to the eraser end if possible), stopwatch, flower pots of varying sizes attached to rope, long tubes of PVC pipe cut to different lengths for different tones, xylophone, plastic straws, tape.

Strategy:

1. Ask children if anyone knows what a vibration is. Ask children to vibrate their bodies. Write vibrate on board. Put a plastic ruler overhanging the edge of a table; hit the ruler and watch it vibrate. Ask: "Can we see the vibration? Can we hear the vibration? Can we feel it?" Show tuning fork; hit; listen; touch vibrating tuning fork to ping pong ball attached to a string. Observe the effect; ask same questions. Pass tuning forks around so children can experience the sound and feel the vibration; note differences in pitch. Hold inflated balloon in front of boom-box speaker with volume turned up loud. "Can you feel the vibration? Where is it coming from?" Place small paper plate with tiny pieces of paper on it on top of speaker. (Boombox must be turned so that speakers are facing up.) Observe what happens to the papers. Explain that all sounds are caused by something vibrating; sound is vibration, etc.

2. How do vibrations from tuning fork and ruler reach us as sound? The vibrations cause waves to carry sound through the air. (You will perhaps need to discuss waves, depending on age and experience of children.) "We know sound travels through air. Does it travel through a solid? Put your ear on the desk. Tap the desk. What do you hear?" Try several such examples. "Does sound travel through a liquid?" Get children to talk about experiences they have had such as talking underwater in the bathtub or swimming pool. Can they hear sound under water? "Try putting a plastic baggie filled with water next to your ear. Have another child speak loudly directly into the other side of the baggie. Can we hear the sound through the water? Does sound travel through a solid, a liquid, and a gas (air)? When was it the loudest?" (through the solid) "Why do you think this may be true?" (The molecules in a solid are more tightly packed, so the vibration can travel without being dispersed as it does in air.)

3. Show a child's xylophone or an autoharp. Strike a short bar, then a long bar and ask children what they heard. Do the same for the lengths of PVC pipe. (Hit the end of the pipes with the palm of your hand.) Make a kazoo out of a plastic straw by flattening one end and cutting it into a triangular shape; blow. As one person blows through the kazoo, another takes a scissors and snips an inch or so off the end. Keep doing this and ask the students to notice what's happening to the sound as the straw gets shorter. Help them relate the shortness of length to high pitch through a variety of such experiences.

4. Now allow the children to experiment and "play" with all the materials so that they develop strong physical understanding of vibrations in all the ways that have been presented. Have a set of 8 identical bottles and a container of water and have them fill the bottles with varying amounts of water. See if they can match the scale of the bottles to that of the xylophone. Give children the opportunity to make a string phone or wire-hanger chime. (Tie a length of string to each end of a wire coat hanger. Put the other end of each string in your ears, tap the hanger against something like a desk. Listen for the ringing through the string.)

Performance Assessment:

1. Children must: Arrange bottles with varying amounts of water in row according to pitch. Explain the relationship between the amount of water and the pitch. Tell what is vibrating. Blow across or just into the top of each bottle and explain how the relationship between pitch and the amount of water in the bottle changes. Hypothesize as to why this might be.

2. Make a stereo coat hanger as explained above. Tell how you might make one with a higher pitch (shorter wire). Cut hanger with wire cutter to get different lengths and different pitches.

3. Make a straw kazoo. Listen to its pitch. Have your partner cut off an inch or two with a scissors while you are blowing. What happens to the sound? Cut off another inch. What do you notice now?

4. Listen to the sound of each tuning fork. (Strike tuning fork on your shoe then put it to your ear.) Arrange the tuning forks from highest pitch to lowest. What do you notice about the forks when they look this way?

Conclusions:

The shorter the tube (or straw, or xylophone key or amount of water in the bottle) the higher the pitch. The longer the tube, the lower the pitch. Pitch, (high and low) is caused by the frequency, or number, of vibrations per time. More vibrations per time ("bigger" frequency) = higher pitch; fewer vibrations per time ("smaller" frequency) = lower pitch.

References:

Science on a Shoestring

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Lenses

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Objectives:

Students in grades 5-8 will discover, through exploration and observation, what lenses are and what lenses can do.

Materials Needed:

concave lenses
convex lenses
Florence glass
plain glass
Fresnel lens
baggie filled with water
spray bottle with water
meter sticks
baggies
solid glass or plastic cylinder
paper
black marker
overhead projector with arm lowered
light box with an arrow on a screen
lens holders
index card with "AMMONIUM DIOXIDE" written
large lens with long focal length

Strategy:

Opening activities

1. Hand out baggies filled with a convex lens, a concave lens and a plain piece of glass. Students explore and discuss what they observe about these objects.

2. Set up the overhead projector removing or lowering the arm. Explain that the overhead projector has a lens with a light below it. Turn off the lights and spray a steady stream of water over and above the lens. Students will observe that a sort of funnel can be seen with a narrowing in the middle. The point at which the spray of water narrows represents the focal point (the point at which the light rays converge).

3. Hold a piece of blank paper over the lens and find the focal point. Children will be able to observe that the light will be smallest and most intense at that point. Then take a black marker and darken the center of the paper. Hold the paper over the lens again at the focal point. Students will observe the paper begin to smoke.

4. Show students the light box with the arrow on it. Observe the direction of the arrow. Turn off the lights and project the image of the arrow on the wall. Students will observe that the image is upside down.

Stations-Students will be divided into cooperative groups of four. Each group will receive an activity sheet with activities to be performed and questions to be answered at each station.

Station #1 - Display convex lenses with various focal lengths. Students will focus the overhead light onto a paper and notice the distance between the lens and the brightest image (this is called the focal length). They will do this for all of the lenses, make observations about the focal length of these lenses and record any other observations.

Station #2 - Students will find an object in the room and describe the image that they see when they look at it through a Florence glass and then a baggie filled with water. Students will determine whether the Florence glass and the baggie are examples of lenses.

Station #3 - Attach two convex lenses, one with a relatively short focal length and the other a long focal length, to a meter stick using lens holders. Students will look through one lens and then both lenses. Then they will focus on an object far away by moving the lenses back and forth on the meter stick. Students will determine what happens to the image and what this device could be used for. (Telescope)

Station #4 - Attach two convex lenses, both with short focal lengths of about 5 cm., to a meter stick using the lens holders. Students will move the lenses back and forth and focus on a written page from a newspaper or the like. Students will determine what happens to the image and what this device could be used for. (Microscope)

Station #5 - Display the Fresnel lens. Students will determine if it is a lens and if so, how it is the same or different from the other lenses.

Station #6 - Mystery Lab! Students will explain what is happening when they look at the words AMMONIUM DIOXIDE through a solid glass cylinder.

Performance Assessment:

Activity sheets from each group will be collected and assessed.

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Mirror Symmetry/Mirror Images

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Objectives:

The intended grade level is sixth grade, but much of this is easily adapted to any grade. This would be at least a two day lesson.

Day 1

1. The learners will understand that different geometric figures will have different lines of symmetry, in different locations and in varying numbers.
2. The learners will develop a definition for symmetry.
3. The learners will use their developed definition of symmetry to predict where lines of symmetry will be located in some other geometric figures.
4. The learners will understand that some figures do not have a line of symmetry.

Day 2

5. The learners will use two mirrors to produce multiple images, eventually developing a mathematical concept to predict what angle will produce what number of images.

Materials Needed:

One mirror per student
One block of wood per student
One rubber band per student
One rubber stopper and pencil per 2 students
One protractor per 2 students
One geometric figure sheet per student
One mirror writing sheet per student
Several round mirrors plus pictures per class
One mirror mirage demo
One long closet mirror
One "WHAT A COOKIE" mirror puzzle

Strategy:

Day 1

Invite a few students to pick up a few coins from the mirror mirage. When they can not do it, ask them why they can not. Next, point out that regular mirrors, such as those found throughout the house, seem to reverse the images that are seen in them. Pass out mirrors. Ask the students if they can read the phrases that are printed on the mirror writing sheet; ask a few students to read a phrase out loud. Try and get the class to agree that a mirror always reverses the images.

Once your students agree that a mirror reverses images, you are ready to fool them yet one more time with the "WHAT A COOKIE" mirror puzzle (words done in red MAGIC marker do not reverse - of course, it is a trick). Do not give them time to think about it or they will figure it out.

Ask the students to hold the mirror in front of them at arms length and look at their nose. Then have them turn the mirror (not their head) so they can see the person next to them, then turn the mirror so they can see the ceiling, then their shoes, then a poster on the wall, etc.

Ask the students to look at the geometric figure sheet. Direct their attention to the rectangle; ask them where they could cut the rectangle into two parts where the one part was a mirror image of the other part. After they tell you, ask them to check their answers with the mirror. Some student will always suggest that you can cut a rectangle on a diagonal; ask the students to check the diagonal. At this point, ask the students to find all of the lines of symmetry (the cut where one part of the figure is the mirror image of the other part) of all of the figures on the sheet.

Day 2

Have the students attach the block to the mirror with the rubberband. Students pair up an make an angle with two mirrors and place a rubber stopper with a pencil stuck in it in front of the mirrors inside the angle. Students arrange the mirrors so they see exactly three images. Point out to the students that this should be a 90 degree angle. Pass out protractors; have the students check the angle. Have the students arrange the mirrors so they can see exactly four images, and check the angle, then five images, and check the angle, then six images, and check the angle, then eight images, and check the angle, then ten images, and check the angle. If you keep doing this and doing it in reverse - that is have the students set the mirrors at a sixty degree angle and count the number of images, then set a fifty degree angle and count images - eventually the students will see a very simple mathematical relationship.

Performance Assessments:

Day 1

Have the students list all the figures on the geometric figure sheet that have no lines of symmetry, all the figures that have exactly one line of symmetry, exactly two lines of symmetry, exactly three lines of symmetry, etc. A suggested grading rubric is 10-11 correct answers is a 4 (meets or exceeds learning expectations), 8-9 is a 3 (satisfactorily meets learning expectations), 5-7 is a 2 (needs improvement), 4 or less is a 1 (does not meet learning expectations.)

Day 2

All students should copy the chart that lists the angles of the mirrors and the number of images that are produced. Ask the students to memorize the chart and be able to reproduce it from memory the next day. The next day the students reproduce the chart from memory. The grade is either 100% or 0%; on the grading rubric the 100% receives a 4 and a 0% receives a 0.

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Color

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Objectives:

Designed for Grades 2 & 3. To develop a relationship between colors in paint & colors in light. What colors make white light. What is Roy G. Biv..

Materials Needed:

Materials listed are for groups of four.
tempera paints - red, blue, yellow, and green
paint brushs - various sizes
color filters - red, green, and blue
colored marking pens
white paper
pencil or pen
a prism
overhead projector - transparency
rainbow viewer
color wheel
crayons
flashlights - 3

Strategy:

The lesson would start with a discussion of color in the world around us. Scientists have learned that white light, such as sunlight can be broken up into colors of the rainbow. The students will mix the colors of paint, in paint the artist can make any color by mixing the three primary colors of paint - red, yellow, and blue. They will use the color wheel to create secondary colors and see how colors in paint mix.

The prism will be used with an overhead projector to create a spectrum on the screen. The lights are turned off, two sheets of paper are placed on the overhead with a vertical opening, the prism is placed at the top of the overhead. A band of color called a spectrum is formed when white light passes through the prism. The prism "bends" each color as it goes through. Each students also looks through the prism directed toward sunlight or lights and should be able to see the spectrum. They write down the colors seen.

Students will blend the colors of light by using color filters and flashlights. A wide range of colors can be produced by blending the three primary colors of light - red, green, blue. The three most important complementary colors in light can be created by combining two primary colors. Red light and blue light create bluish red called magenta. Blue and Green Light form Cyan. With green light and red light we create yellow.

When we look through filters, the world takes on a very different look. Filters only let certain colors thought to your eyes. Colored glass, cellophane and plastic are examples of filters. Use a red marking pen to draw an apple, then draw a blue bird, a green tree, an orange flower, purple grapes and a yellow sun. Look at each drawing through the red filter. Does the apple disappear or seem to turn color? What color does the apple appear to be? How about the blue bird? Look at each drawing through the green filter and then the blue filter. Graph out the results.

Performance Assessment:

The students will write down the colors of Roy G. Biv - which are the colors of the rainbow. Red, Orange, Yellow, Green, Blue, Indigo and Violet.

Graph out the results from each group.

	FILTERS		
Drawings	**Red**	**Blue**	**Green**
Red Apple			
Blue Bird			
Green Tree			
Orange Flower			
Purple Grapes			
Yellow Sun			

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Light

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Objectives:

The main objectives of this mini-teach is for primary students to understand the Nature of Light. This will be accomplished by examples and demonstrations.

Materials Needed:

This is for a group of eighteen students.

1. A large pan of water approximately 2'x 2'.
2. A slinky toy.
3. Three flashlights and transparent red, green, and blue paper to cover the flashlights.
4. About 10 pieces of poster board for boxes to make the periscope.
5. You will need poster board for the color wheels also.
6. One piece of waxed paper and transparent paper.
7. Three equal strips of transparent plastic 1" x 4".
8. White, green, red, yellow, and blue paper.
9. 1 brick.
10. Modeling clay.
11. Two cardboard tubes.
12. Twenty-five mirrors approximately 2" x 5".
13. Model or chart of the human eye.
14. Scissors.
15. Crayons.
16. Quart jar and ruler.

Strategy:

Model Construction:

1. Take the large pan of water approximately 2'x 2' and fill with water.
2. Take the three flashlights and transparent red, green, and blue paper. Cover the end of each flashlight with each paper. Use tape or rubber bands.
3. In making the periscope; form a rectangular box approximately 10"x 4" by cutting and folding with the poster board. Quart milk or juice cartons can also be used. Cut two slits on opposite ends of the carton at a 45 degree angle. The mirrors should be placed in the slit.
4. In making the kaleidoscope; take the three transparent plastic strips. Make into a triangular shape. Tape the whole triangular tube with dark contact tape. Put the sequins and glitter in a transparent I D packet or on a cardboard card about 2"x 2".
5. In performing the after image demonstration you need a piece each of white, green, red, yellow, and blue paper.
   a. In a brightly lit room place a sheet of red paper next to a sheet

of white paper. Stare at the center of the red paper as you count to 30.

b. Now look at the center of the white paper. Count to 20. What color seems to slowly form on the white paper? Is the color really there. Record the results you witness on the chart.

The color **you stare at**	**Red**	**Blue**	**Green**	**Yellow**
The color you see on white				

6. In making the see through brick you will need a brick, flashlight, a piece of cardboard 4 small mirrors, modeling clay and scissors.
   a. Cut a narrow slit about 2 inches deep in the middle of a piece of cardboard about 4" x 4".
   b. Use some modeling clay to prop the cardboard upright in front of the flashlight.
   c. Place the brick a little way in front of the card.
   d. Use the modeling clay to fix the mirrors to match each other in an 45 degree angular fashion.
   e. Shine the flashlight through the slit.
7. In showing the bouncing back of light you will need a large mirror, two cardboard tubes, a flashlight and some books.
   a. Use the books to prop the mirror upright.
   b. Hold one tube at a 45 degree angle with the end touching the mirror.
   c. Ask a student to hold the second tube at a matching angle.
   d. Shine the flashlight through the tube you are holding.
8. In making a rotating color wheel you will need enough poster board. You can get 6 wheels per poster board.
   a. Use 4 feet long piece of string.
   b. Cut out 4 inch circles with a compass.
   c. Divide the circle into 6 pie shaped triangles with the following colors; red, violet, orange, blue, green and yellow.
   d. Poke 2 holes three quarters of an inch from the center of the circle.
   e. Thread the string through the holes and tie the ends together.
   f. Put a twist in the string like with a jump rope, spinning it around in that motion.
   g. Then pull outward on both ends of the string quickly and tightly.
9. In making a pinhole camera you will need to do the following:
   a. Cut off a strip of poster board approximately 12" x 4", Mark off into equal sections, pie shaped triangular sections. Tape together.
   b. Paint the inside of the box black. Make sure you completely cover the color of the poster board.
   c. Tape a piece of tracing paper over one end of the box.
   d. Tape a piece of sturdy brown paper to the other end of the pinhole camera.
   e. Use a pin to make a small round hole in the middle of the brown paper.
   f. Cover your head and the tracing paper end of the box with a cloth or towel.
   g. Point the camera at the window and look through the tracing paper end of the box about six inches away. You should see an upside down window. Be patient the image is not crystal clear.

10. Fill a quart jar about half full put a ruler in the jar.

Performance Assessment:

At the conclusion of the mini-teach students will be able to answer the following questions:

1. What is the main source of light energy?
2. What is the speed of light?
3. What happens when light hits something it cannot pass through?
4. What happens when light passes through water?
5. What are the primary colors?
6. Is white light composed of colors?
7. What happens when the lights are off and you shine a light on an object?
8. Where does light enter the eye?
9. What instrument operates like the eye?

Conclusion:

Students will understand and be able to explain the Nature of Light.

References:

Physics by Amanda Kent and Alan Ward, **Seeing Is Not Believing** by Barbara Taylor, **More Science Activities** by John Falk, **Physics Experiments for Children** by Muriel Mandrell.

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Make Waves

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Objective:

Students in grade six will discover, through exploration, the basic characteristics of waves.

Materials Needed:

wave machine	Tuning fork
Ripple tank	Oil
Funnel	Plastic bottle (one per student)
Bucket	Paper
Cookie Sheet	Sand
Water	Food coloring
Slinkies	Spring

Strategy:

Opening Activity: Students will come to the front of the room and lock arms. The teacher will pull and push on the first person in a side to side motion thus creating a longitudinal wave. Then the teacher will pull and push on the first person in a forward and backward motion creating a transverse wave. Students will be asked for their observations. Students will then be asked to tell of any personal knowledge of the different types of waves.
Students will divide into cooperative groups and explore six stations. A recorder will write down any discoveries or observations made by the group.

Students will be divided into groups of four.

Stations
1. Wave machines- Students will explore bell wave machines. These are available at most high schools.
2. Ripple tank- Students will observe the patterns that water waves make.
3. Students will fill a funnel with sand and observe patterns made when the funnel is set in a swinging motion and the paper is dragged under it.
4. Students will observe water wave characteristics in a large bucket of water and in a shallow cookie sheet. Students will observe waves in a shallow medium and in a deep medium.
5. Students will observe a tuning fork placed in a cup of water. The water will splash showing vibration.
6. Students will make a wave in a bottle by filling a plastic bottle with a mixture of oil, water and food coloring.

Group Activity: Teacher and students will explore waves through observing the motions of various slinkies and springs.

Performance Assessment:

Reporters from each group will report the discoveries each group made at the six stations. The teacher will record these observations on the blackboard. The group will summarize their results and come to a consensus with regard to their observations of waves. Students will be asked to describe the characteristics of waves and give a definition of a wave on paper.

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Homemade Instruments

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Objectives:

These activities can be used by all grade levels.
Students will identify what sound is and make musical instruments out of household items.

Materials Needed:

8 glass bottles
spoon
straws
shoebox
scissors

Strategy:

Activity 1:

1. Take a soda straw and pinch one end flat.
2. Cut off the corners to form two little reeds. The fact that it's cuttable means you can make it into an oboe.
3. Hold the reeds in your mouth without squeezing them.
4. Now blow hard.
5. Carefully cut small holes along the length of the straw about one inch or so apart.
6. Blow in the straw while you cover and uncover the holes to play simple tunes.

Conclusion:

The two reeds opening and closing at high speed first allow air to flow into the straw and then stop the flow. The vibrating air is what produces the sound.

Activity 2:

l. Take 8 glass bottles and fill each bottle with a little more water than the one before.
2. Take a spoon and tap each bottle to hear a different sound.

Conclusions:

When you tap each bottle, it makes the bottle vibrate. The pitch of the note depends on the amount of water in the bottle. The pitch of note is lower with more water.

Activity 3:

l. Take a shoebox and cut a hole in the top.
2. Place several large rubber bands of various widths around the box to make a guitar.

Conclusion:

The plucking of the rubber bands causes them to vibrate producing various sounds. The thicker the band, the lower the note. The thinner the band, the higher the note.

Evaluation:

80% accuracy is successful.

References:

Herbert, Don, **Mr. Wizard's Supermarket Science**, Random House, NY

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Understanding Waves

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Objectives:

1. Eighth grade students will gain an understanding of waves.
2. Eighth grade students will gain an understanding of the properties that all waves have in common.
3. Eighth grade students will gain an understanding of the types of Waves.

Materials Needed:

1. Ripple Tank
2. Tuning Forks (3)
3. Rope (Make two pieces 2 meters each)
4. Paper (Notebook)
5. Pencils(1 for each group)
6. Springs (Slinky) & (Door Screen)

Strategy:

Arrange five stations:
Station 1 Ripple Tank
Station 2 Tuning Forks and bottle of water
Station 3 Rope tied to door knob or other solid object
Station 4 1 Spring (Slinky)
Station 5 1 Spring (Screen Door)

Divide the class up in groups and have each group take a station. Have the students work with waves at the different stations and write down two observations at each station. Student groups should spend at least five minutes at each station. When all groups have spent time at each station, then class should take their seats and share on board the observations made at each station. Each group should have a scribe and a scribe can be appointed to record all observations on the board. When all has been recorded, the teacher can go over the terms with diagrams and use observation. The terms that need to be covered are: waves (mechanical and electromagnetic), transverse, longitudinal, amplitude, wavelength, frequency, and speed. Next let the students go back and explore the different stations.

Performance Assessment:

Each student in the group would have the same grade

5 points ----------5 observations
4 points ----------4 observations
3 points ----------3 observations
2 points ----------2 observations
1 point ----------1 observation

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Making Sounds

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Objectives:

The students will be able to:
- observe that vibrating objects can produce sounds.
- observe that the faster an object vibrates,the higher the sound or pitch.
- observe the slower an objective vibrates, the lower the sound or pitch.

Materials needed:

Activity 1: 24 small mouthed glass bottles of comparable size, 4 metal spoons, 1 large water pitcher and 4 funnels.
Activity 2: 30 wooden rulers with each student at his or her desk.
Activity 3: 4 shoe boxes, 8 small pieces of plywood, 2 large bags of rubber bands and 4 pairs of scissors.

Strategy:

Activity 1: PLAYING THE RULER
Students will hold a ruler on a table with half its length over the edge. Pluck the end of the ruler and listen to the sound. Now move the ruler so there is only a short length over the edge of the table and pluck it again. Then try the same thing with a long length of ruler over the edge of the table. As you move the ruler, what happens to the sound? If more of the ruler is over the edge of the table, does the sound become higher or lower? Then the students will record data from what they observed.

Activity 2: BOTTLE ORGAN
The students will identify how the height of an air column affects the pitch of sound. Students will work in groups, they will pour different amounts of water in each bottle, bottles will be labeled A, B, C, D, E, and F. Next, they will gently tap each bottle with the metal spoon to determine the difference in the pitch produced. Then students will record data on a chart to show which bottle has the highest pitch.

Activity 3: RUBBER BAND GUITAR
Each student will be issued materials needed to make a rubber band guitar. Students will take scissors and cut a hole in the middle of a shoe box. Next, stretching several rubber bands of various lengths and thickness across the top of the box leaving a gap of about half an inch (1cm) between each one. Students will pluck rubber bands to discover what sounds are vibrating. Next they will add two pieces of wood about half an inch square as wide as the box. They are called the bridge. Teacher will ask the questions: What happens when you pluck the bands without the bridge? Is the pitch of the notes made by the looser bands higher or lower? Students will record data.

Reference:

Kaner, Etta. **Sound Science.** Addison-Wesley Publishing Company, 1991

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Light - Reflection - Illusion

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Objectives:

1. The student will understand **The Law of Reflection** in practical application as it applies to a plane mirror.
2. The student will understand that a distance of an object in front of a mirror is equal to the distance of that object behind the mirror.

Class Strategy:

- Introduce lesson with Phenomenological Floatation Illusion and Magic Box trick
- Students investigate five stations which illustrates the **Law of Reflection**
- Group analysis of data with explanation and use of overhead
- Group Activity - Making of magic box

Floatation Illusion

Material--Mirror 36" x 52" --chair--curtain

Discuss with the students about floating like Michael Jordon -- Inform them you have mastered the art of floatation. Stand on chair, jump down over mirror (straddle it). Remember that you are perpendicular to the audience. Have the assistants pull back the curtain. Lift your leg closest the students. To them it will seems as if you are floating but what you are doing is standing on the leg behind the mirror. Float for a few seconds-let yourself down- have assistants close curtain.

Magic Box Illusion

Material--Box 18" x 24" x 10" with top--contact paper to cover the box--cardboard flap which will fit diagonally in the box--Mirror or Metallic polyester (enough to cover flap)--Cut window in front of box approximately 15" x 18".

Procedure - Attach mirror to flap and place flap diagonally in box - This gives the image of an empty box. Place an object (rabbit) behind flap - Explain to your students that the box is empty - put hand inside - remove top - pull out rabbit.

STATIONS OF INVESTIGATION

Station 1 How High To Place the Mirror

Procedure - Pose the students with the question "How high do I have to hang the mirror in order to see all of myself including my shoes?" Two students hold the mirror against the wall - a third student looks at himself in the mirror, and a fourth measures the maximum height of the mirror off the floor. Attach the mirror at that height and let all the students see themselves in the mirror.

Questions to be answered

1. Does the distance from where you stand to the mirror affect the image of yourself in the mirror?

2. Would a shorter person have to move the mirror in order to see his feet?
3. Can you draw the path of light rays that you see coming from your feet?

Conclusion
Because the image of a person is exactly the same distance behind the mirror, the height of the mirror to the floor is always 1/2 of the person's height (the angle of incident is equal to the angle of reflection.)

Station 2 Funny Reflections
Materials--Unframed square or rectangle mirror
Procedure - Write the following words in large even capital letters **CHEEK, BIKE, DECIDE, BOX, CHICK, CHOKE, BOOK)** cut each in half. Place mirror vertically against the paper.

Questions - Will this work with all printed words? Which letter, when cut in half will appear whole?

Strategy - The image in the mirror shows that all images are actually found behind the mirror.

Station 3 Look at Yourself as Other See You
Material--Two square or rectangular mirrors without frames
Procedure - Have one student stand the two mirror perpendicular to each other. Student observation. Place mirrors in one plane. Make Observations.
Questions - 1. Why did the left hand appear on the right in the perpendicular mirror? 2. How do light rays travel from the object to mirror and back to the observe's eye? 3. What happened to your image when the mirrors were straightened?
Conclusion - The light ray of the object (which is yourself) are reflected in 90 degree angles from one mirror to the other and then back to the eye. In a regular straight mirror, the rays bounce right back to the eye.

Station 4 The Cool Candle Flame
Materials--Rectangular piece of window glass and two identical candles
Procedure - 1. Mount the glass vertically between bricks or books. 2. Fix one candle in front of the glass sheet. 3. Fix the second candle an equal distance in back of the glass sheet. Light only the first candle. Align the second so that the flame of the first seems to be atop the second (if looking from the front).
Questions - 1. Why can you hold your hand above the second candle? 2. What is the distance of the first candle to the glass? What is the distance of the second candle to the glass? Compare the distances.
Conclusion - This shows that the image of an object in a mirror is located behind the mirror, exactly the same distance from the mirror as the object is in front of it.

Station 5 Pong Video Game
Material--pong Video Game and television
Procedure - Play the game - record the winner
Questions - Who won? Why?
Strategy - Just as the tennis ball is reflected off a wall-a narrow beam of light is reflected from a mirror (**the angle of incident is equal to the angle of reflection.**)

Note: Patterns for Magic Box may be obtain at The Museum of Science and Industry or call me at school and I will send you a copy.

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Sound

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Objective 1:

Children shall "discover" that sound waves can be directed with a megaphone and collected with an ear trumpet.

Materials Needed:

Each group of four or five students will need a megaphone/ear trumpet (roll and staple poster paper into a conical shape) and a ticking device (clock or timer).

Strategy:

1. Participants speak to one another--first normally, then with hands cupped around their mouths, and finally through a megaphone. They talk about any differences they notice.

2. Participants listen to one another--first normally, then with hands cupped behind their ears, and finally through an ear trumpet. They talk about differences they notice.

3. Each member of the group counts how many paces away he can hear a ticking device--first with the unaided ear, then with an ear trumpet. The group will compare the distances, and draw a conclusion.

Conclusion:

Sound waves can be collected and directed into our ear and increase our ability to hear.

Objective 2:

Children shall "discover" that sound travels differently through a solid, a liquid, and a gas.

Materials needed:

Each child or group will need a 40 cm piece of 5 cm flexible tubing: an aluminum foil pan: 60 cm of string: tape: a stethoscope: a can of soda: a drinking glass: and a 3 liter tub of water.

Strategy:

After each of the following activities the students name the material the sound traveled through (a solid, a liquid or a gas). They record through which state of matter they heard better.

1. Hold one end of a piece of tubing to your mouth and the other end in your ear as you talk.

2. Tape a foil pan to the middle of a piece of sting. Bang the pan against your desk and listen. Twist the ends of the string around the tips of your index fingers. Place those finger in your ears. Bang the pan and listen again.

3. Listen as you knock on your desk. Place a stethoscope (or your ear) against the desk as you knock again.

4. Open a can of soda. Listen to the bubbles. Place the can next to your ear and listen again.

5. Listen to the classroom next door. Place the open end of a drinking glass against the wall and your ear against the bottom of the glass and listen again.

6. Volunteer students listen to tapping sounds made against a tub of water. Then place one ear into the water while holding the other ear shut and listen again.

Conclusion:

Sound is transmitted best through solids, next though liquids, then through gases.

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An Awareness Of Light Made Simply Fun

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Objectives:

1. To remediate sensory-motor deficits in Learning Disabilities students through scientific activities that study light.

2. As a result of these scientific observations the students will:
   - -observe basic properties of light reflection and refraction.
   - -relate reflection and refraction to daily life.
   - -know that the angle which light hits a smooth surface is the same as the angle reflected.
   - -make a visual graph (outline, graph, diagram, or flow-chart), and write a simple sentence interpreting the data.
   - -explain in own words by whole language methods what concepts are in operation.

Materials:

Group:

Darkened room, for sensory exploration of found objects (have sufficient materials a handful for each student), flashlights, two 12" x 12" mirrors, one 12" x 12" plexiglass, one 12" x 12" mirror "book" (that can be opened and closed) one 3-cornered 12" x 12" mirror, four 2" x 2" x 4" grooved blocks (for ends to hold mirror and plexiglass squares), one 12" x 12" squared hard-board (with opening at bottom for hand and arm), sheet of 8" x 11" white paper, 2 simple-lined drawings (a star and a small cat face), pencils, a wide-mouthed glass jar or cup of water, a penny, a walk-in 4' x 4' triangular tripod kaleidoscope covered inside with mylar or mirror and raised 3' above the floor, a few 4" squares of aluminum foil, an overhead projector.

Individual:

For kaleidoscope-3 3" microscope slides, 3 3" squares of mylar, duct tape in different colors.

Strategies:

In a darkened room:

1. We need light to see.

Given a handful of small objects in a bag, student will identify what he has, using cognitive processes - sensation, perception, thinking, reasoning, or memory.

2. Hand-shadows.

Using light from an overhead projector, make hand-shadows.

3. Dust helps us see light beams.

A flashlight beam is directed at a mirror square on the floor. Make chalk dust and sprinkle near the beam. Dust bounces from the beam to the ceiling where the mirror reflects. Various angles can be used and observed.

4. A Light Trick.
A 4" square of mylar is attached to a wall. A bright light is projected on the mylar from above. The mylar now appears as a dark spot. Student stoops and rises from the floor until s/he sees the angle at which the light is reflected. Changing the height of the mylar gives more fun.

5. Tinkerbell.
A penlight laser beam can be used with #4 and #5. Try it in the dark.

Lights On:

1. Seeing Me.
Walk under the kaleidoscope, see oneself, make gestures, count images, differentiate between your left and right images.

2. A Little Kaleidoscope.
Make a 3" kaleidoscope from the lengths of 3 microscopic slides forming a triangle with the long sides, wrapping 3" sheet of mylar around it, and covering with a choice of colored duct tape.

3. We Can't Be Smooth Again.
A smooth piece of aluminum foil is observed before and after it is crumpled.

4. Is The Pencil Broken?
A pencil appears to bend in a glass of water.

5. Is The Penny Gone?
A penny disappears in a glass of water.

6. A Pretty Sight.
Given a mirror book [two hinged plane mirrors], students will decrease the angle from 180 degrees to 2 degrees and count the number of reflected images that small found objects make, as the angles change.

7. Cornered Images.
Observe images in a 3 cornered mirror.

8. Make Copying Easy.
Use the plexiglass square between a line drawing of a star and a sheet of paper. Copy the drawing by reflected light.

9. Can You Write Right?
Using a simple line drawing of a cat face between a hard-board shield and a mirror, finger trace the cat. Looking only at the mirror for guidance, try to write something on a sheet of paper.

10. Twinkle Twinkle Little Red Star.
Use a penlight laser in activities using mirrors.

Conclusions:

Light travels in a straight line.

We see objects by light reflected to our eyes. We cannot see in the dark and identify by cognitive awareness of sensation, perception, reasoning, memory, thinking processes to interpret our environment.

The image of an object is seen exactly the same distance behind a plane

mirror, as the object is in front of the mirror.
Transparent materials bend light.

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Pitch

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Objectives:

1. To use the phenomenological approach to problem-solving.
2. To demonstrate the Scientific Process of Inquiry.
3. To observe that the pitch of a sound varies by the length of the vibrating medium.
4. To make a musical instrument by varying the length of the vibrating soda straws.

Materials:

Apparatus needed for a class: overhead projector, overhead projector pens, transparencies, metric rulers, pens, pencils, scissors, tape, 8 21" soda straws per student, open pipe or donated carpet end tubes cut to specified lengths, African Musical Instruments from the Field Museum, tape recorder, instrumental musical tape, computer banner, poster of President Clinton playing the saxophone.

Strategy:

1. Saw open pipes or carpet end tubes to the exact specification in **The Physics Teacher**, May 1986, p.313. (1.32, 1.20, 1.04, .99, .88, .78, .70, .66 meters)
2. Use the open pipes for the phenomenological introduction to pitch.
   Place the carpet end tubes on a table from tallest to smallest.
   The teacher picks up each tube and listens in silence. (Background noise is very useful here.)
   Ask for student volunteers to come up and listen to each pipe.
   Ask the students what did they hear.
   Ask the students what did they observe about the tubes.
   Ask the students what changed as a result of the difference in the length of the carpet end tubes.
3. Make a web of their answers on the board or paper.
4. Make up a hypothesis from the web of observations.
   For example, does the length of the carpet end tube determine the pitch of the sound it produces?
5. Test the hypothesis by making Straw Pan Pipes to these exact specifications: #1. 21.4 cm, #2. 19.0 cm, #3. 17.1 cm, #4. 16.1 cm, #5. 14.3 cm, #6. 12.8cm, #7. 11.4 cm, #8. 10.7 cm
6. Let students work in cooperative learning teams making the Straw Pan Pipes.
7. Allow the students time to practice playing a specific song together.
8. Have all cooperative learning teams play the selected song together.
9. Ask students to write a paragraph telling what they learned from this experience. While they are writing play an instrumental tape.
10. Have another teacher bring in the poster of President Clinton.
11. Indicate Mr. Clinton came to see what they have learned about pitch.
12. Ask for student volunteers to read their compositions.

Performance Assessment:

Use a xylophone the next day and ask what do you observe about the pitch.

Ask them to take their Straw Pan Pipes home and practice playing a specific song for class the next day.

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Plane Mirror Images

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Objectives:

The student will know:

1. Where a plane mirror image is (**behind the mirror, not on the mirror**)
2. How the light reflects (making equal angles)
3. How the "extra" images are formed with multiple mirrors

Materials needed:

Two large (foot square?) mirrors, two sheets of clear plexiglass-also about 1 foot square, four candles, some matches, large paper (about 2 feet x 2 feet), Something to hold up the mirrors, scotch tape, some markers or crayons

Strategy:

I do this as a class demo, after the students have experimented with plane mirrors.

Part I:

Place a large sheet of paper on demo table or desk top. Put one mirror facing the students. Place a candle in front of the mirror, light it, stand behind the desk (so the students can see!) and ask where the image is.

Replace the mirror with a piece of plexiglass. Turn out the lights for the best results. Again, ask where the image is.

Put a second candle randomly behind the plastic. Have the students tell you where you should move it so that this extra candle is exactly where the image is (centered under the image's flame). When everyone agrees on the location it is in the right spot. You should call their attention to this. It is only right when everyone agrees. There is only one perfect spot!

Mark the location of the mirror and both candles. Use magic markers or crayons.

Now have a student use a meter stick to aim at the image. Draw this line of sight on the paper. With a different student and a new color, get a line of sight from some other direction.

Move everything off the paper. Turn on the lights. Hang the paper up on the board.

Pick one of the lines of sight. Point out that the light comes off the mirror and goes along this line to their eye. Also point out that we have picked out only two of the thousands of possible light rays. Ask how the light got to that point on the mirror. Point out that it did not come from the candle behind the mirror--it was not lit! They should tell you that it came from the front, lit, candle.

Draw the path from this candle to the point on the mirror where it reflected out the line of sight. Ask about the angles the light makes when it hits the mirror. They should look equal. You can measure them with a protractor.

Repeat this for the other line of sight. Its angles will also be equal, but not necessarily equal to the first set of angles.

Ask about the distance of the object and image to the mirror. They will be equal.

Part II:

With a new piece of paper: Set up two mirrors at right angles to each other, facing the students. Mark the location of the mirrors. Place a candle in front of the mirrors and light it.

Ask how many images they see. (There should be three, if there are four, the angle is not quite 90º. Play with it.)

Replace the mirrors with plexiglass. Check the angle.

Work on the image locations, one image at a time. Do the two "outside" images first. The third, central image is the tough one. After you have all three, mark the locations of all of the candles.

Lift one mirror and ask how many images there are now. Remind them that images look lit. Point out that this is a simple image, from one mirror.

Replace that mirror and remove the other. Repeat discussion. Replace that mirror.

Have a student use a meter stick to draw a line of sight to the center image. A second student can draw a line of sight to the center image from some other direction.

Turn on the lights and hang the paper on the board.

Follow one of the lines of sight back to the mirror. Ask how this light ray got to that point on the mirror. If it came from the candle, the angles will not be equal. Draw the light ray so that the angles are equal. (You can do this without measuring. It will seem to come from the far side image.) It will be seen that this light ray came from the other mirror. It got to that mirror from the object candle, making equal angles at that first mirror, reflecting to the second mirror and then out.

What can you say about the distances of all the images? (The mirror is halfway between the candle and each of its images. Thus, the object distance equals the image distance for each image.)

Conclusions:

For Plane Mirrors:
Image distance = Object distance

Light reflects making equal angles.
(i.e. Angle of Incidence=Angle of Reflection or ji=jr)

Performance Assessment:

Ask the question: How large a mirror do you need to see yourself from top to toe?

Rubric:

This can be solved using either *Multicultural Applications:*

The bubonic plague was spread throughout England. The colleges were closed to reduce the chance of spreading the disease through the student population. Isaac Newton spent the next 18 months experimenting with light and researching his observations in Latin. Before he was 25 he published them in a book called "Optics."

[Return to Physics Index](http://www.iit.edu/~smile/)

Hear The Light?

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Objectives:

The students will illustrate and describe a circuit which uses a tape player, inductor, and flashlight to modulate a light beam.

The students will construct a flashlight transmitter using the materials below.

Materials:

Modulated Laser from "Snack Book", 22 gauge wire, iron nails, flashlight per group, two ear plugs per group, two alligator clips per group, batteries and battery holders for two batteries and four batteries.

Strategy:

Step 1

A. Introduce topic to class by recording your voice into tape recorder, then playing it back to students by way of the modulated laser. (Teacher will have to construct this prior to this lesson.)

B. Have tapes on hand with a variety of music from different cultural groups and play this music to class by way of modulated laser.

C. Pass the tape recorder around and allow each student to say a few words into the recorder. Play back to students by way of laser.

D. Elicit questions and responses from students about what they are seeing, hearing, etc.

Step 2

A. Explain the parts of the transmitter portion of the modulated laser by starting with the tape recorder. Every student should be familiar with a tape recorder.

B. Next explain that a simple ear plug is used. Be sure to explain that the ear piece has been cut off, the wires separated and the alligator clips attached. Pause to make sure class is with you on each step.

C. Next explain that the tape recorder is connected to a wire coil (induction coil). Most students will not know why so you will come back to this part.

D. Point out the flashlight which all students should also be familiar with. Explain that we have interrupted the path between the batteries and bulb and rerouted the path through the induction coil.

Step 3

A. Why do we need the tape recorder and flashlight connected to the induction coil?

B. What have we recently studied that looks similar to this coil? (electromagnets)

C. What did we learn about electromagnets and how did we make them?

D. Suggest that if we make an electromagnet and change the voltage or current going into that electromagnet, we will also change the magnetic field. Pass out nails, wire, battery holders and batteries to each group. Each group will test how many paper clips can be picked up with two batteries attached. Then test how many can be picked up with four batteries. Did the magnetic field change? (Yes, it got stronger)

Step 4

A. Now that we see the magnetic field changes as the voltage changes, what is changing the voltage in the modulated laser? (the variation in the music or sound) Since music is made up of different notes and each note is made up of a different number of vibrations, the varying vibrations create a varying push in current or voltage. This varying voltage changes the magnetic field in the induction coil. What exactly does this mean and why is this important for the working of this laser? (In an induction coil, each loop in the coil interacts with the magnetic fields produced by the other loops in the coil. A self induced voltage is produced as this magnetic field changes. Demonstrate that voltage changes when the magnetic field changes by attaching a coil to a galvonometer and passing a magnet through the coil).

B. The induction coil pushes the current towards the light bulb. Since the music is changing the voltage going to the induction coil, what must be happening to the light? (It is also fluctuating or modulating)

C. Go over the meaning of the two terms: induction coil and modulate. Now say that what we have just described is the transmitter. This transmitter transmits or sends a signal to somewhere else.

Step 5

A. Hold up the solar cell and speaker/amplifier. This is our receiver. In other words it receives the signal that we are sending. Does anyone have any ideas about how this receives the signal? (Solar cell changes the light energy to electrical energy. Since the light beam is modulating, the electrical impulses from the solar cell are also modulating. As we described earlier, this changing electrical impulse or changing voltage is going into our speaker and causing a vibration in this speaker which is equal to the vibrations from the music at the source. So what happens? We hear the music that originated in the tape recorder from the receiver across the room).

Step 6

A. Each group will make the transmitter part of the modulated laser and test it on teachers equipment. Have a contest on who can hear the signal from the furthest away.

Performance Assessment:

Students will use the modulated laser they built as a guide and illustrate the circuit involved in making this work. They will then describe in detail how the modulated laser works.

Rubric:

5 points: Circuit is illustrated completely and accurately. The explanation is clear enough for anyone to follow the instructions and build a modulated laser.

4 points: Circuit is illustrated as above but explanation lacks clarity.
3 points: Circuit is illustrated but not labeled, and explanation lacks clarity and details.
2 points: Circuit is not illustrated completely and explanation unclear.
1 point: Illustration and explanation lack details necessary to understand the lesson completely.

Multicultural Applications:

Have various tapes from different cultural backgrounds to play for the students. Also ask the students how this lesson can apply to our lives and our future. What are the future uses and applications of this type of communication device?

Reference:

Doherty, Paul, **The Exploratorium Science Snackbook**, Exploratorium, 3601 Lyon Street, San Francisco, CA 94123, 1991.

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Comparison of Images Formed by Plane, Cylindrical and Spherical Mirrors

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Objectives:

1) To demonstrate that all mirrors reverse the image front to back and that the apparent right to left reversal in a plane mirror is a result of this front to back reversal.
2) To describe plane, cylindrical and concave mirrors in terms of curvature about horizontal and vertical axes.
3) To help students recognize that right to left and top to bottom reversals occur simultaneously and occur only in curved mirrors.
4) To discover that left to right reversals (and top to bottom reversal) occur when the axis of the object is parallel to the curved axis of the mirror and that no left to right reversal occurs when the axis of the object is along a linear mirror axis.

Apparatus Needed:

Plane mirror, cylindrical mirror, concave mirror of short focal length. The cylindrical mirror can be made by gluing a piece of aluminized mylar inside a 120º section of carpet roll.

Recommended Strategy:

1) This exercise can be done anytime during the year as an attention grabber, an introduction to, or review of mirror images.
2) In order to avoid confusion which is associated with left and right in observing mirror images, it seems best to describe orientation along a horizontal axis in terms of some objects in the room such as the window side and door side.
3) Beginning with a plane mirror ask the students to observe the image of their left hand. Ask if the image is reversed left to right. Most will reply that it is. Then ask if the image is reversed to bottom. Point out the inconsistency of their answer and let them sit with that for a while.
4) Using a plane mirror ask the student to cover their eye which is on the wall side; ask them which eye is covered in the mirror (wall side or window side.) Also ask if the image is reversed top to bottom. Direct the students to turn the mirror through 90º, make observations and answer the same questions.
5) Using the concave side of a cylindrical mirror, repeat No. 4 above, asking the same questions.
6) Using the concave side of a spherical mirror, repeat No. 4 above, asking the same questions.
7) Summarize student observations on the board and help the class explain their observations.
8) Observations in a cylindrical mirror can be extended by viewing the image of

two different colored arrows crossed at 90º. Ask the students to turn the object through 90º and observe what happens to the image. Ask them to turn the mirror through 90º and observe what happens to the image this time.

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I Can See A Rainbow!

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Objective:

As a result of this lesson, students will be able to identify the colors of a rainbow using the mnemonic ROY G BIV. They will also recognize primary colors of light. The student will have an understanding of light blending to form new colors. Finally they will answer the question; Why is the sky blue?

Vocabulary:

Retina   Indigo   Magenta   Violet   Primary Cyan

Materials:

1. Three slide projectors or overheads, one of these should be a overhead.
2. Three color filters blue, red, yellow.
3. Various objects of bright colors.
4. Scissors, crayons, pencils each student will need these.
5. White cardboard.
6. Diffraction paper.
7. Construction paper, one sheet each of red, orange, yellow, green, blue indigo, and violet.
8. One glass of water, 1/2 teaspoon of coffee creamer.
9. A flashlight
10. A diagram of the human eye.

Strategy:

The teacher will need to have a cardboard circle measuring 31/2" diameter for each student. Divide the circle into eight. The construction paper should be cut into arches to form a rainbow. Place the beginning letter of the color at the top of the arch i.e., R on the red, O on orange, etc. The three projectors should be set up in such a way that all three light beams will meet on a white screen. One color filter is placed near each projector. The diffraction paper should be cut into a small enough square to be tape over the light of the overhead. Spoon coffee creamer into water, do not stir let powder sink to bottom. Set aside for latter demonstration. Using the diagram of an eye explain the following: Light entering your eye hits the retina stimulating cones, then a message is sent to the brain telling you this is the color.

Activity 1:

The teacher will begin this activity by showing the students a rainbow. This is done with the previously describe overhead-diffration paper set up. Cut on projector, ask students to describe what colors they see. Next have students take the corresponding color and tape it to the board forming a rainbow. When this is complete ROY G BIV is viewed, the teacher should tell students this is the way to remember the colors of the rainbow.

Activity 2:

Place a red filter over one projector showing a red beam of light on a screen. Then do the same with the green filter. This should result in the two colors of light forming yellow on the screen. This should be done with red and blue to make magenta and blue plus green to make cyan. Explain that these colors are called primary colors of light because when combined they make up all the colors of the rainbow. The mnemonic for this is RGB. Finally combine all three to form white light. Next have students step in the path of white light, look at their shadow. What colors do you see?

Activity 3:

Place two filters on the overhead not over lapping. Then have students place an object in front of the light. Look at the color the object takes on. Discuss.

Activity 4:

Project a red light on the screen. Have students stare at it for 30 seconds. Turn off light. Do you still see a red screen? No the red cones in your retina are tired. The color you see is from the cones that are not tired.

Activity 5:

Why is the sky blue? The teacher will shine the flashlight onto a glass from above and move slowly down the back. Note the water color. Explain to the class that the particles of powder cream scatter the light from the flashlight. Putting the flashlight behind the glass causes the blue light to scatter aside allowing only orange-red light to be seen. Placing the light above the glass causes less light to scatter and more blue light is seen. Thus the water looks blue. When applied to the atmosphere, the flashlight is the sun, the water, the sky and the creamer are air particles.

Activity 6:

Give each student a wheel (circle), a red, blue, green crayon, pencil. Have the students color the wheel using two colors on each. Next push the pencil through the center. Spin the wheel to see a new colors.

Performance Assessment:

Give the students the following story. Their reply should use a rainbow diagram, name each color on it, tell why the sky is blue also give an explanation of primary colors used to form all colors.

Once upon a time it was a rainy day. Karlene and her friend April waited for the showers to end before going out to play. Once outside April said "WOW look in the sky, a rainbow!" Describe what the third graders had seen and why?

Rubric:

5 points Answers correctly with clear sound multi-faceted logical arguments (diagrams, examples, sketches, etc.)

4 points Answers correctly with clear explanation and a diagram.

3 points Answers correctly but reason is unclear.

2 points Partially correct with effort toward explanations.

1 points Answers with no supporting evidence.

0 points Answers of "I don't know."

Multi-cultural Project:

The classroom bulletin board can be set up with a rainbow. Highlighting the mnemonic ROY G BIV. Children of multi-cultures can be looking up at it. The caption reads LOVE COMES IN ALL COLORS.

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"You may now enter the Holodeck."

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Objectives:
The main objective is that students will be able to demonstrate a working knowledge of the science of holography:

1. The students will be able to tell the story of the history of holography.
2. The students will be able to differentiate between six different kinds of holography, and use that knowledge in problem solving.
3. The students will be able to compare and contrast photography and holography, and therefore be able to explain the basic characteristics of a hologram along with the reasons for such attributes.
4. The students will be able to list approximately 15-25 present applications of holography in our world around us, from technology to advertising, from biology to architecture, and many more, and will know one particular application in more depth.
5. The students will be able to draw a diagram of the set-up for making a hologram along with labels and definitions of the parts of the set-up.
6. The students will be able to explain "what's going on" in the process of making a hologram, and they will be able to make a hologram.

Materials needed:
A variety of holograms for the students to observe
A set of cut-out pictures to teach the history
A picture of the teacher when you were younger: one for each group
A hologram (at least one per group)
Optional: Stereoscopic glasses and pre-printed images (Can be purchased at American Science Center)
Simple costumes for three different personalities
A class set of "Area of Specialization" packets (Envelope containing a journal article of an application of holography; a different article for each student
Supplies for making a hologram: laser, film, developing chemicals, mirrors, watch with a light, rubber gloves, glass plates with clips, 3 tubs.

Strategy:
Day One: Have students observe a prepared display of a variety of holograms, whatever you can get your hands on. Have one person from each group be "recorder" and write down the comments the group made as they enjoyed the holograms, along with each student's favorite and why. Discuss their observations. Let them tell you all they saw and all their questions, but don't feel like you have to address all these questions now. They will be answered throughout the unit.
Have the students meet with their groups and, based only on what they saw today, give the best definition for a hologram they together can compose.

Day Two: Have the students gather 'round you on the floor for "story time". As you tell the story of the history of holography, put up symbols cut out of construction paper which represent each of the most important points. (I used 11 pictures, including dates, in many colors). Hand out a picture page to each

student containing an abstract collage of the symbols you had put up in sequence. Have them, in their heads or in pairs, practice telling the story using their symbols. Randomly choose a child to follow your symbols and retell the story. Ask that student to "get stuck" at least once so the class can assist. (This takes pressure off the chosen one and keeps the class on their toes.) Write the word "hologram" on the board. Discuss it's Greek origin. Have them guess what each part of the word means. (whole picture)
Have the students meet with their groups and, based on what they've seen, heard, and done yesterday and today, REVISE yesterday's definition of a hologram into a little more precise educated guess.

Day Three: Begin by quizzing students on the history by using your symbols. Then continue by beginning to introduce the differences between different types of holograms when you have someone call you to leave the room. Dress as a business man, storm in and ask the "experts in training" to solve your problem: You, as Mr. Chang, are required to create an appealing way to counteract counterfeiting of credit cards. Your boss has suggested holograms as a possible solution, but you know that there are MANY kinds of holograms, and you have no idea which kind your need for your purpose. Tell them you'll return later for their response and leave. Change your attire two more times creating two new personalities with two completely different needs and functions for holography. Come back as yourself and play dumb: make them explain what happened while you were gone. As they do, list the needs as characteristics of holograms under each character's name. For example: Mr. Chang - mass production, inexpensive, attractive, small, etc. Then teach them about six different types of holograms. Assign each group one character as a customer. Have them develop an argument for which type of hologram to use and why they would want THAT type of hologram as opposed to others. Stress the fact that there is no wrong answer; the argument is what's important. Find another excuse to leave, come back as the characters, and make them defend their recommendation.
Have each group meet to update and revise their definition of a hologram.

Day Four: Hand each group a picture of you and at least one hologram. Discuss with them the "rules of brainstorming," (emphasizing no dumb answers, write down everything, analyze answers LATER.) Have them write these at the top of the handout. On the rest of the handout, have them list the ways photographs and holograms are the same and how they are different. After approximately 15 minutes, meet together as a class and discuss. Use this time to show them the basics of how a photograph is made using a lens to focus the image on the film, and how a hologram is made with two beams which cover the film. Compare for them the negative of a photograph and the "negative" of a hologram. Now show them the stereoscopic viewer. If the main difference between a photograph and a hologram is 2-D verses 3-D, what's the difference between a stereoscopic (3-D) photograph and a hologram. Let the groups work together on comparing them. (Stereoscopic photo: only one 3-D view, Hologram: many different 3-D views). Discuss their results.
Have the groups revise their definition of a hologram.

Day Five: Discuss the importance of having an area of specialization (optometrist, podiatrist,...) Pass out a manila folder to each student labeled "TOP SECRET, Area of Specialization." In each student's folder include an UNIQUE journal article concerning an application of holography. (There are TONS of very interesting articles in the library: holography in chocolate, holography in airplanes, drying cement, telegrams,...) Send each of them to find a secluded location to read and become informed on their area. When they

return, they are to be prepared to give a 10 second summary (1-2 sentences) on what their area is about and a 10 second summary using creative words to grab someone's attention explaining the most amazing aspects of their area. They also must be knowledgeable about their topic because they could be questioned further if someone shows interest in that topic. When they return, make each child stand, state their name, and state their summaries. Have them end each response in "ma'am," so you understand they're done. For example, You: "State your name." John: "Special Agent John Miller, ma'am." At the end of everyone's report, allow the class to ask specific questions of any of the special agents concerning his/her area of specialization.
Have the groups meet to revise their definition of a hologram based on the past 5 days.

Day Six: You will be gradually sketching a typical set-up of a holography lab on the board as you go through this period. Begin by getting them to compare holography to photography and separate the process into three steps: taking the photo, developing, and viewing. Compare this to holography: making the hologram, develop it, and reconstruct or view it. As you sketch each section (the lasers and object for making the hologram, the holographic plate for developing, and an additional light source to view it), review the basic physics principles concerning holography: smooth and diffuse reflection, interference patterns, and diffraction. (These have all been covered by the time we study holography.) Moire patterns can be used to demonstrate interference. If time, or perhaps the following day, blindfold four students, create a "fake" darkroom, and have them demonstrate the motions of "how to make and develop a hologram" as you explain what they are doing.
CULMINATION ACTIVITY: Have them make a hologram. (As experts, tell them, "You may now enter the holodeck.")

Performance Assessment:
Give me your best definition of a hologram: (Be careful not to say too much or be too wordy or use more words to say what you could've said in less words.)
Answer, as an expert with supporting reasons, the question a stranger inquires of you:

1. List some present applications to holography. As an expert, where do you see holography being used in the future?
2. Why are TWO beams of light necessary to create a hologram?
3. Why is a hologram said to be a "window with a memory?"

Expected Results: Students should show an understanding of the practical applications of holography both as an art and as a science, demonstrate an understanding of the basic principles of physics that apply to holography, and show an understanding of the characteristics of a hologram that make it unique and valuable.

5 Points: Answers are creative, clear and accurate. Student shows an in depth understanding of the physics in holography: reflection, interference, and diffraction.
4 Points: Answers are accurate and creative. Going into explanations the specifics of interference is not necessary. Questions answered completely.
3 Points: Answers accurate, but lacking creativity. Fails to demonstrate understanding of interference.
2 Points: Answers all questions with considerable ammount of effort. May be lacking a little in accuracy and creativity.

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1 Point:   Answers demonstrate little effort.
0 Points:  No effort.
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Sound

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Objectives:

After this lesson, the student should be able to

1. relate the pitch of sound to the length of a vibrating object.

2. define words (pitch, source, medium, detector, air conduction, and bone conduction).

3. examine hearing acuity using the tuning fork by means of air conduction and bone conduction.

4. discuss how Europe contributed to earlier conventions.

Strategies and Activities:

Activity 1: the session will begin by having the instructor define vocabulary words.

Materials Needed:

rulers, straws, and glass bottles

Activity 2:
(a) increase the length of ruler/straw (vibrating object) to get a lower pitch.
(b) decrease the length of ruler/straw (vibrating object) to get a higher pitch.
(c) record the observation made.

Activity 3:
(a) fill one bottle with water almost to the top and fill another bottle half full.
(b) blow across each bottle and listen to he highness/lowness of pitch of each bottle.
(c) tap each bottle and listen to the highness/lowness of pitch of each bottle.
(d) record the observations made.

Activity 4:
(a) each group will take eight pop bottles.
(b) each group will fill the bottles with the appropriate amount of water needed to produce an octave.
(c) each group will produce the piano scale by blowing across the bottles.
(d) record the observations made.

Performance Assessment:

Why was the pitch lower for the bottle with less water when you blew across the top of the bottle? Why was the pitch higher when you tapped the bottle with less water?

Rubric:

3 Answer provided clear explanation
Applied principles learned in class
Used previous example in class to support answer
2 Explanation was somewhat unclear
1 Little or no explanation
0 No attempt made to answer questions

Conclusions:

If the vibrating column is shorter, the pitch will be higher and vice versa.

Materials Needed:

tuning forks, stop watches, and rubber sticks

Activity 5:
(1) students will compare time in seconds for air conduction and bone conduction to examine hearing acuity using the tuning fork.
(2) they will work in groups of four (examiner, timer, recorder and subject).
(3) the examiner will tap a tuning fork with a rubber stick.
(4) then, the examiner will place the tuning fork on the bone protruding behind the right ear (mastoid process) for 3 trials on the subject.
(5) simultaneously, the timer will time how long any sound was heard (even the faintest sound that was heard using the tuning fork) during each trial.
(the timer will start the stopwatch as soon as the tuning fork is tapped).
(6) the recorder will record the time in seconds.
(7) the subject will hold his/her hand up as long as he/she hears the sound.
(8) afterwards, the examiner will follow the same procedure for the left ear.
(9) next, the examiner will place the tuning fork at the midline of the forehead above the level of the eyebrow for 3 trials on the subject.

Conclusions:

The time that the sound was heard occurred longer for air conduction than bone conduction. Greater energy was required for sound to travel for bone conduction than air conduction.

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Sound/Pitch

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Objective:

To discover how pitch can be changed in instruments that are plucked (strings), blown (woodwinds and brasses) or hit (percussion).

Bottle Music

Materials Needed:

Each group needs 5 bottles of the same size (empty pop bottles work well), water. Optional: Funnel (for filling bottles).

Strategy:

1. Fill one bottle with water almost to the top. Fill the second bottle about three-fourths full, the third half full and leave the last bottle empty.
2. Blow across the top of each bottle. Listen to the highness/lowness of each bottle's note.
3. Record your data.

Conclusions:

When you blow across the top of each bottle, it makes the air inside the bottle vibrate. Small air spaces vibrate more rapidly than large air spaces. When there is little air in the bottle, you produce a high note. When there is more air, the note is lower.

Underwater Recorder

Materials Needed:

Each child needs his recorder, duct tape and a tall container of water.

Strategy:

1. Cover all the finger holes in the recorder with duct tape. Blow gently into the recorder and you should hear a single, low-pitched note.
2. Take a deep breath and blow into the recorder while you push it into the water. What happens to the pitch of the note?
3. Take another breath and blow into the recorder again while you pull it up out of the water. How does the sound change?

Conclusions:

When you blow into the recorder, the air inside it vibrates and you hear a note. The pitch of the note depends on the length of the column of air inside the recorder. When you push the recorder under the water, the water fills up the tube so the column is shorter. You hear a high-pitched note. As you pull the recorder out of the water, the column of air becomes longer and the note sounds lower.

Pipes of Pan

Materials Needed:

Five pieces of bamboo or hollow plastic (PVC) piping, cut into the following sizes: 2, 31/2, 5, 61/2 and 8 inches; non-drying modeling clay and sticky tape.

Strategy:

1. The pieces of pipe are cut to different lengths ranging from 2 to 8 inches.
2. Push a piece of modeling clay into one end of each tube.
3. Arrange the pipes in order of length, with the shortest pipe at one end and the longest pipe at the other end. Tape the pipes together so the open ends are exactly level with each other.
4. To play your Pipes of Pan, place the edge of the open end of the pipe against your lower lip and blow gently across the top of the pipes.
5. What do you notice about the pitch of the notes from the different pipes?

Conclusions:

You should discover that the longer pipes give lower notes and shorter pipes make higher-pitched notes.

Glass Xylophone

Materials Needed:

For each group: 5 glass containers that are the same size (such as empty pop bottles), water, wooden spoon or mallet, funnel for filling bottles.

Strategy:

1. Fill one bottle with water almost to the top. Fill the second bottle about three-fourths full, the third half full, the fourth a quarter full and leave the last bottle empty.
2. Tap the side of each glass gently with a wooden spoon. Each glass will ring with a note of a different pitch. Which glass makes the highest sound and which glass makes the lowest sound?

Conclusions:

When you tap each glass, it makes the glass vibrate. The pitch of the note depends on the amount of water in the glass. With more water, the pitch of the note is lower.

Other activities which were demonstrated include Elastic Band Guitar for exploring stringed instruments and Tapping and Hitting for discovering pitch in percussion instruments.

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Reflection Relay

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Objective:

To use the laws of reflection to bounce a beam of light around a classroom to hit targets and to attain the lowest elapsed time to hit the targets.

Materials Needed:

3 pocket sized mirrors for each group
one filmstrip projector
several bullseye targets

Suggested Strategy:

Rules:

1) The light beam must strike each of the three mirrors before hitting the target and there may be obstacles that the beam of light will have to be directed around.

2) The team members must cooperate to direct the beam of light to the target while using all three mirrors to change the light's path.

3) Each team must hit a different target.

4) Each team will be given up to five minutes of preparation time before the clock is started to time the 'official' time.

Scoring:

1) Each team will be timed with the lowest time being the winner.

2) No team will be allowed to use more than two minutes to accomplish the task.

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Wave Motion

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Objectives:

Adaptable to grades 1 to 12

The student will be able to:

1) Identify the frequency, amplitude and phase of a wave.
2) Identify and explain the difference between a transverse and longitudinal wave.
3) Relate the concept of vibration to frequency and pitch.

Materials needed:

ring stand, cone-shaped cup, string, slinky, springs and ropes (two meters long), shoe box, rubber band, paper clips, coffee can, match, ripple tank, overhead projector, paper straws, rice crispies, can with top covered with a balloon, salt, piece of cloth, baster

Strategy:

Hang a cup filled with salt, with a hole in the bottom, from a ring stand.

Pull the cup and allow it to swing back and forth over construction paper.

Notice the straight line made by the salt streaming from the end of the cone.

Then, pull the construction paper along the table and let the pendulum continue to swing. Notice the formation of a wave made by the flowing salt. Have students form groups to experience activities on wave motion.

Activities:

1) Shout (do not blow) at the top of a can covered with a balloon with rice crispies on top. (vibration)

2) Pluck a rubber band which is lined with paper clips and stretched across a shoe box. (transverse wave)

3) Hit a coffee can filled with smoke. (longitudinal wave)

4) Use a slinky, rope or springs to form longitudinal or transverse waves.

5) Make waves in a ripple tank placed on the overhead projector to produce circular waves. (transverse) Place objects in the water to show that the wave moves, but the objects do not. Also, place a wooden block in the water to show incident and reflected waves.

6) Form a human wave by having ten people stand in a line, largest to smallest, with arms locked together, and pull the last person sideways. (longitudinal wave) Then pull the last person forward. (transverse wave) In both cases, the waves will be reflected back along the line.

7) Form standing waves by tying a rope to a fixed object and moving the rope up and down. (incident and reflected wave)

8) Form a standing wave by connecting one end of a string to a timer and placing the other end over a pulley. Connect weights to the end of the string hanging over the pulley. (170 gm) Show a wave in phase and out of phase by using a rope. Have students put their fingers on the vibrating string to locate the nodes and see that the wave is out of phase.

9) Relate vibration to frequency and pitch of instruments.
   a. Slower vibration causes a lower pitch as shown by scratching a cloth slowly, then faster to get a higher pitch.
   b. Blow into a baster and notice the change in pitch caused by squeezing the end of the baster to change the level of water in the baster.
   c. Make a straw instrument by cutting the tip of the straw on each side and blowing into the straw while cutting the bottom of the straw at the same time. Notice the change in pitch.

Culminating Activity:

Make chicken pluckers by putting a hole in the bottom of a paper cup, pulling a string through and tying it on the inside of the cup. (Attach a paper clip to the string inside.) Pull along the outside string with a wet paper towel to produce a loud squawking sound.

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How Sound Travels

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Objectives:

1. To demonstrate that sound moves through different states of matter.

2. To observe that sound moves better through a solid than it does through a liquid or a gas.

Materials needed:

Demo: bell, tuning fork, cork, balloon, two spoons, musical triangle, slide whistle, two wood blocks, windup clock, 12" ruler, large jar filled with water, paper bag, metal can and lid, plastic container with lid, metal bar, music box motor.

Each group needs: meter stick, windup clock, self-sealing plastic bag filled with water, a block of wood (the same thickness as the plastic bag of water), two plastic cups with one end of a string through the hole in the bottom of one cup and the other end of the string through the hole in the bottom of the other cup. Knot the ends of the string to stop it from pulling out of the holes (home-made telephone), a third plastic cup with a string attached to the bottom of the cup, a metal rod.

Strategy:

Have the children identify different sounds made behind a screen (or desk) by using various materials: ringing a bell, hitting a tuning fork on a cork, blowing up a balloon and releasing air by stretching the neck of the balloon as the air escapes, tapping two spoons together, striking the musical triangle, blowing a slide whistle, hitting two wooden blocks together and ringing an alarm clock. Record the children's answers on the board. Show the materials used and check against the predictions made.

Hold a ruler over the edge of a desk and vibrate it asking such questions as: What is happening? What is your evidence? What is always happening to an object when it is making a sound?

Strike a tuning fork on a cork and quickly lower it into a glass of water. Ask the questions stated above. Does sound travel through other things?

Activities:

Demo: Does sound travel through paper? through plastic? through metal?

1. Put a ringing alarm clock in a paper bag.
2. Close the bag. Can you hear the clock ringing now?
3. Repeat steps 1 and 2 using a plastic container and a metal can.

Does sound travel through water?

1. Fill a glass jar nearly full of water.
2. Have one student cover one ear with her/his hand. Put the other ear against the glass jar.
3. Ask another student to hit two spoons together under water. Do you hear a sound?

Sound travels through different kinds of matter. Sound travels through gases, liquids and solids.

Group: What kind of matter does sound travel best in--air, water, wood or metal?

A.
1. Hold a plastic bag of water against one of your ears. Cover your other ear with your hand. Have someone hold a ticking clock against the bag of water. Listen.
2. Keep the clock in the same place. Remove the bag of water. Listen.
3. Place a block of wood between your ear and the clock. Listen. Do you hear the clock best through the air, the water or the wood?

B.
1. Place the clock 20 cm away from your ear and listen to the ticking.
2. Have your partner hold the clock at the 20-cm mark on the meter stick. Place your ear at the end of the meter stick and listen.
3. Have your partner hold a metal rod to your ear and place the clock against the rod 20 cm away from your ear. Listen. Does sound move differently through some solids than it does through others?

C.
1. Take the plastic cups (telephone) and hold your cup to your ear while your friend talks slowly and clearly into the other cup. Keep the string tight. How does it work? What is vibrating? How do the vibrations of your friend's voice reach your ear?
2. Can a third person talk and listen if another cup with a string is attached? Take the separate cup with the string and attach it to the first line. Keep all strings tight while one friend talks into one cup and the other two friends listen. Can you hear the message of the third party? How many lines could you attach? Does each addition weaken the vibrations?

Draw three squares on the board and in each square draw molecules spaced accordingly to illustrate the three states of matter: gas (molecules far apart), liquid (molecules closer together) and solid (molecules closest together). Have students identify the different states of matter for each square.

Finally, take the small music box motor, hold it in your hand and allow the music to play. Ask the students if they hear the music. Now place the music box motor on top of your desk or on a large surface area and listen to the melody. Is there any difference? Can the students hear the music now? Why?

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Mystery of the Mirrors

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Objectives:

[Grades 1-2-3]
Students will be able to:

1. Tell what mirrors are used for.
2. Compare objects in two mirrors at right angles to each other and describe what happened.
3. Demonstrate how a periscope is used to see around corners.

Materials Needed:

The following materials are needed for each group of 1-10 students:

3 milk cartons	1 small candle	1 quarter
2 small mirrors 2" by 3"	1 pencil duct tape	2 wood blocks
8 large mirrors 3" by 6"	drawing paper	primary paper crayons
1 long mirror 4 feet	scissors	newspaper
nametags	1 clock	

Strategy:

Instructor:
Hold up a mirror. Ask "What is this?" (mirror) Ask "Where do we find mirrors?" accept all answers. Since mirrors are found in many places, let's find out what they are used for. We will be Mirror Detectives and solve the mystery of the mirrors by observation and discovery.

Divide students into 4 groups. Each student will get paper and pencil and select a partner to work with. Each group will go to one of the designated stations and write in complete sentences what they observe or discover. Students will move from stations when teacher rings bell. After observing all stations students will come together to share information. All facts are written on chalk board and each student copies for science notebook.

Procedure:

Station 1:

Stand up two 3x5 mirrors and tape them together so that they form a right angle to each other. Face a clock toward the two mirrors. Read the clock. Try to read a page of a book in the mirror. Look at yourself. Try to comb and brush your hair.

You can read the clock and book. You look strange and can't seem to comb and brush the side of the hair you mean to.

Place a quarter on the table between the mirrors. Then as you slowly bring the free ends of the mirrors closer together, additional quarters come into view. Your money seems to grow until both mirrors touch the quarter.

Station 2:

Take two 3x5 mirrors and two blocks of wood (same size) and attach the mirrors to the wood with duct tape. Set the two mirrors facing each other about two inches apart. Place a pencil between them. A parade of pencil images appear in the mirror behind the pencil.

Turn the front mirror a bit. Now you see a curved parade of pencils. Change the angle a bit more. The parade curves more sharply.

Station 3:

Make a periscope. Use a milk carton (1 quart size). Cut a hole on one side of the carton near the top and a similar hole on the opposite side, the same distance from the bottom. Tape two pocket mirrors (2x3) in place parallel to one another, at a 45 degree slant.

Hold the periscope up to your eye and look through the lower hole. Now go to a corner and hold the periscope so that one hole is sticking out. Look through the other hole. You can see what is above you and on the opposite side of the periscope. You can see around corners.

Station 4:

Place a long mirror (4 feet long) low enough so that three students can sit in front of it. Students should have on name tags. Students will sketch the upper part of body looking through mirror. Other students in this group will look through newspaper for a word that describes how they feel about themselves (great, happy, strong, etc.). Cut it out and paste it on the picture they sketched. Students will see themselves as others see them and name tags will be on opposite sides and backwards.

Expected Results:

Mirrors are used to see ourselves and to see how to do things.
To see small images of large objects.
To see behind you, around corners, and over things.
To make things look larger and to multiply images.

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Light

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Objectives:

(Grades 4-6)
1. Students will be able to calculate the angle of reflection and the angle of incidence and discover that these angles are equal.
2. They will discover that light disperses through a medium and a variety of colors can be seen. This will resemble a blue sky and sunset.
3. They will discover that light refracts when entering different media.
4. They will discover that light is pure energy.

Materials:

1. Aquarium, high intensity flashlight, Coffee Mate, mirror, protractor
2. prism, screen (use typing paper mounted on a desk size paper clip)
3. beaker, pencil
4. box with any object inside

Procedure:

1. Fill an aquarium three fourths full of water. Add about one half teaspoon of Coffee Mate to the water and mix this solution. Place a flat mirror in the bottom of the aquarium. Shine a high intensity light beam from a flashlight into the side of the aquarium toward the mirror. Turn off the room light and view the angle of reflection and the angle made by the light to the mirror (angle of incidence). Place a protractor along the base of the aquarium. Measure the angle of reflection and the angle of incidence. The angle of reflection and the angle of incidence will be equal in each case.

2. Using the same aquarium and solution, shine the high intensity light through the solution parallel to the base. The water will appear blue like a blue sky because blue light disperses. When the students view the light from the far end of the aquarium, the light appears orange like an orange sunset.

3. Fill a beaker half full of water. Place a pencil into the beaker. The pencil will appear to be broken at the point where the pencil meets the water. Explain that light rays are refracted at angles when they travel through different media.

4. Place any object inside a box. Tell the students that you will hold up the object and they will get five seconds to view it after which you will hide the object and they will describe it. On the count of three turn off the lights in the room and hold up the object. Ask the students to describe the object. They will say they can't. Ask them why. They will say there was no light. Explain to them that light is pure energy. Tell them that pure energy can only by used at that moment. We will never have that particular light beam again. Draw the light rays on the chalkboard to emphasize.

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Light And Color

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Objective:

For primary students grade K-3 in elementary school.

1. Students will understand how light travels in straight lines by exposing them to various activities.
2. Students will be exposed to the basic behavior of different colors in light.
3. Students will learn where light come from by using a laser.

Equipment and Materials:

For the entire class

1. red, green, and blue filters
2. 3 flashlights
3. transparent tape or rubber bands
4. a white wall
5. a darkened room
6. pencil
7. tracing paper

Recommended Strategy:

1. Use transparent tape or rubber bands to attach a colored filter to each of the three flashlight.
2. Darken the room before mixing green and blue light, guess what color will result. Then turn on the green and blue flashlights and combine the lights on the white wall.
3. The color you see on the wall, making of greenish blue is called cyan.
4. Now guess what will happen when you mix green light with red light, test your guess.
5. Guess the result of red light mixed with blue light. Then test your guess.
6. Place the three flashlight on a table, one at each end and one in the middle. The light of all three flashlights should come together on the white wall. Stand between the flashlights and the wall. How many shadows do you have?
7. What colors are they? Experiment by covering or turning off one light at a time. How do the colors of your shadows change.
8. Create circle patterns. With the pencil, trace the circle found on this paper. Make sure the lines are heavy and dark.
9. Turn the patterns over. Keeping the pencil patterns face down, place the patterns on the stiff cardboard. Go over the lines of the patterns with a ballpoint pen. Lift the patterns. You will see faint circle on the cardboard.

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Spherical Mirrors

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Objectives

After this exercise the students should be able to:

1. Construct ray diagrams of images in spherical mirrors;
2. Find images of objects in spherical mirrors;
3. Distinguish between convex and concave mirrors;
4. Distinguish between converging light and diverging light.

Materials Needed

A. By student: calculator, protractor, shiny serving spoon, paper, pencil.
B. By teacher:
   1. Spherical mirror (dinner plate size).
   2. Box, painted black on the inside.
   3. 2 light sockets, one painted black.
   4. Light bulb.
C. Optional equipment: Laser, mirage device.

Classroom Strategy

A. Pre-class preparation:

1. Place one light socket on one of the inside sides of the box. Place the other light socket on the outside of the box, directly above the socket on the inside. Make sure the sockets are not on the bottom of the box. Now place the mirror at a distance which is twice the focal length of the mirror and insert the light bulb in the socket on the inside of the box. Adjust the mirror and the box so that you get a real image of the bulb above the socket on the outside of the box (the light needs to be on to get a clear image!). The apparatus is now ready for the demonstration.

B. Classroom Procedures:

1. Set up the above apparatus prior to the class. Begin the class with the demonstration. Point out the object and its **real** image. Note that the image is inverted when compared to the object. This will be explained during the activity in class. If a laser is available, shine it over the top of the image and parallel to the principal axis. This beam will pass through the focus and over the top of the object. Another ray, directed over the image and through the focus will reflect off the mirror parallel to the principal axis and over the object. These rays are the same ones used in constructing a ray diagram, but now the students can see **why** we use these rays.
2. On the overhead projector, construct a ray diagram of what was just observed. If the laser was used, refer to the rays demonstrated. Have the students construct the diagram on paper as you do it on the overhead.
3. Have the students take out the serving spoon. Pass out paperclips and have them bend it so they have an object that will have a definite top and bottom. While viewing the concave side of the spoon, move the paperclip from far away from the spoon to close-up. Have the students note if the image is inverted or upright. Do the

same for the convex side of the spoon. For the concave side, the image is inverted until you move inside the focus, where it will then be upright. The convex side never inverts the image.

4. On the diagram on the overhead, show how the parallel light in a concave mirror meets at the focus. Then show what happens to parallel light that reflects off the convex mirror. Distinguish between converging and diverging light.

5. Briefly show a convex diagram and where the image appears to be coming from. This will be explained in a future lesson.

6. Either put a problem on the overhead or have a handout with the problem on it, and have the students work it, using a ray diagram. A homework assignment will then follow.

7. The formula for finding image, object, and focus distances can also be presented, as well as height of the image and object. Or, these can be presented in a future lesson.

8. An image device, consisting of two concave mirrors face-to-face, can be purchased to project a real image of an object. This will produce the same type of image as the light bulb. The device can be displayed on the desk for students to ponder.

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Polarized Light

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Objectives

1) To expose students to the basic behavior of polarized light.
2) To help students discover that light can be polarized by reflection from a non-metallic surface as well as by passing through certain crystalline materials.
3) To develop a model which can account for differences in light behavior using a second set of polaroid filters.

Equipment and Materials

2 polarizing filters with axes parallel to the edge. 2 polarizing filters with axes 45º to the edge. Distinguish from the above filters by placing them in colored holders. microscope slide, cheap scotch tape (Le Pages or Tuck are good.) plastic champagne glass, shiny metallic surface (aluminum foil), shiny non-metallic dark surface (student folder may be useful here.)

Recommended Strategy

1. Place one polaroid filter between eye and a light source (window is good); slowly rotate the filter. Note any changes in light intensity.

2. Place a polaroid filter in front of a light source. Slowly rotate a second polaroid filter between your eye and the other filter. Note any change in light intensity.

3. Put a single strip of scotch tape on one end of the microscope slide, and several pieces crossed on top of one another on the other end. Place the slide between the filters and slowly rotate one of the filters. Slowly rotate the slide. Note any change in light intensity or other phenomenon.

4. If available, show the segment on polarized light from **Newton's Apple**.

5. View light **reflected** from both a shiny metallic surface and from a non-metallic surface using one filter and rotating it slowly. Note any change in light intensity of the reflected light.

6. View a plastic champagne glass placed between two polaroid filters. Now place the glass on the glare area of a shiny non-metallic surface, and view it through one polaroid filter. Ask students to explain the origin of the colors even though only one filter is used.

7. Obtain a second set of polaroid filters (in colored holders). Compare the behavior of light through both sets of filters when one filter is: a) rotated, b) placed in front or behind the other, c) flipped over.

8. Challenge students to develop a model which will explain the difference in the behavior of light in 7 c above.

9. View a liquid crystal display through one polaroid filter rotating the filter slowly. Note any change in light intensity. A good explanation of the way that a liquid crystal display operates and other information about polarized light can be found in the student publication, **Chem Matters**, April 1984, pp. 8-13.

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Colors

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Objective

1. Students will understand what colors are in white and other colors of light.
2. Students will understand complementary colors and that colors we see are the result of some colors being removed from white light.

Apparatus Needed

An overhead projector
Various colored pieces of plastic (the whole spectrum if possible)
Various pieces of colored paper

Recommended Strategy

Starting with a clear piece of plastic on the overhead screen, ask, "Has anyone heard that white light contains other colors. How can white be separated into its colors?" Answers of prism, etc. may be suggested. None of these should be present. Place a piece of red plastic **accidentally** over the clear piece. "Is there red light in white?" Yes, because you can see the red light coming through. "What about other colors in white? Are there other colors in yellow and other colors?" Have class find out by overlapping colored pieces of plastic and holding them up to the light. Data table can be developed and discussed.

Ask, "Why is the asphalt street so much warmer than the sidewalk if you are walking in bare feet? What colors come through black?" None, the colors are changed to heat. "What happens to the colors that don't come through various colors?" Changed to heat too. "How could we check this out?" Thermometer.

We can get our eyes to automatically show what colors are removed from light when we look at any color. Place a white piece of paper on the desk with a small x in the center. Place a colored piece of paper next to the white page and stare at the center of the colored piece, counting to 30. Quickly shift your gaze and concentration to the x on the white sheet. The color removed from white light (the complementary color) when you looked at the first color should now appear. Make a table of the complementary colors. To test your results, select a color and place a small piece of its complement in the center. Count and shift your vision. If your colors are complementary, they will switch places. Discuss how this is useful; looking at objects under mercury or sodium vapor lights at first appear the wrong color, but eventually the colors seem more normal. The concept that colors are removed from white light could be discussed by asking what colors are removed (complementary colors) by looking at colors of clothing around you and what colors are removed from light by leaves.

Finish up by projecting on the overhead a flag with green stripes in place of red with opaque stripes of masking tape for the white, yellow field in place of blue, and paste-on opaque stars. Play the Star Spangled Banner. About half-way through the song remove the overhead slide, but have everyone continue to stare at a spot on the screen. The normal colors will appear for the rest of the song.

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Reflections Of

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Objective(s):

The student will be able to:
1) define reflection.
2) observe and compare the angle of incidence with the angle of reflection.
3) find the number of images reflected by two mirrors when the mirrors are placed at different angles.
4) demonstrate reflection of light using a kaleidoscope.
5) illustrate how multiple images can be produced with a particular kaleidoscope arrangement.

Apparatus Needed:

Paper, rulers, small mirrors, protractors, small object (e.g. beads, coins), plastic strips, clear contact paper, sequins, beads, duct tape, scissors.

Recommended Strategy:

1) Students draw a broken line on a piece of paper, next a straight line is drawn extending from the broken line at any angle. A small mirror is set upright at the point where the two lines meet. Students then turn the mirror until the reflection of the dotted line is in line with the real dotted line. Next students line up a ruler with the reflection of the straight line in the mirror. The reflection of the straight line in the mirror is extended and drawn on the paper. Next the angle of each side of the broken line is measured with a protractor.

2) Students use two mirrors, a protractor and an object to find out how many images are formed when the two mirrors are placed at different angles.

3) Students construct a kaleidoscope using three plastic strips taped into a triangle with duct tape. In between two clear contact circles are put a few sequins and beads. This circle is looked at through the plastic triangle strips.

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Polarization

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Objectives

1) Students will learn basic facts of polarization
2) Demonstrate some phenomenological activities illustrating interference patterns.
3) Make "take-home" project of the interference pattern.

Equipment and Materials

Microprojector
Crystals of:
- sugar
- epsom salt
- salol
- mica
- salt

Clear plastic box
Polarizing films
Cellophane tape
Microscope slides

Recommended Strategies

Review light waves and experiment with polarizing film.
Demonstrate the nature of polarized light showing that polarized light travels in a single plane instead of the 360 degree of unpolarized light.

Demonstrate the interference pattern of various crystals which are placed between two polarized films on the microprojector.

> When light passes through a polarized film, the many color rays (or wave lengths) which make up the white light travel at various velocities and break up or interfere with another ray .
>
> A wave length or white light is then subtracted and shows the complementary color-- the color that is left when white light is subtracted. This is the interference pattern.

Demonstrate light reflecting from a smooth surface such as plastic is polarized. The reflecting light comes to the eye in a single plane.

Show that many digital read-outs are also polarized.

Have students make a take-home project demonstrating interference patterns by placing a number of small pieces of cellophane tapes randomly on a microscope slide. Then view the slide placed between two polarizing films.

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Waves

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Objectives:

Students will be able to define, label and demonstrate the following vocabulary words: wave, wave motion, longitudinal wave, transverse wave, pulse, crest, energy trough, amplitude, frequency, reflection, rarefaction, refraction and compression.
Students will be able to state the properties that a medium must possess in order that waves may be transmitted through it.
Students will be able to tell the essential difference between a longitudinal and a transverse wave.
Students will be able to know how to make a longitudinal or compressional pulse and a transverse pulse.
Students will be able to determine the time it takes a pulse to travel down the rope or a slinky.
Students will be able to understand that a wave is a means of transmitting energy.

Apparatus Needed:

Marbles, grooved ruler or stick, hose or rope, large pan of water, cork, small stone, ripple tank, medicine dropper, overhead projector, coil spring, meterstick, watch, slinky, string or fishing line, smooth pole or stiff wire, curtain rings, movies [Bd. of Ed. 2797-82 and 4209-22].

Recommended:

1. Place five or six marbles in a groove so that they touch each other. Roll another marble against the end of the line of marbles. The vibration of waves will be transmitted through the line and the marbles on the end will roll away. Roll two, then three and so on. Observe what happens.

2. Move the hose or rope up and down to make transverse waves. Drop the stone into the water. Observe what happens.

3. Fill the flat pan about half full of water. Place the pan on an overhead projector or tabletop. Fill a medicine dropper with water. Allow one drop of water to fall into the center of the pan. Allow another drop to fall near the edge. Notice what happens in each. Sketch the pattern of waves that are seen.

4. Move a rope up and down. Describe and explain what kind of waves are observed.

Cut equal-lengths of string at least one meter long. Tie a curtain ring to one end of each string. Attach the free end of a piece of string to every fifth coil of the slinky. Slip the curtain rings onto the pole [or wire], and then suspend it from the ceiling. Observe: send a longitudinal pulse down the spring by pinching together several coils of the spring and then releasing them. What kind of pulse is this? [longitudinal or compressional]

What happens to the shape of the pulse as it travels down the wire? Quickly pull the free end of the slinky to one side and then return it to its original position. What kind of pulse is this? What happens to the shape of the pulse as it travels down the string? Determine the time it takes a pulse to travel down the string. Change the amplitude of the pulse and again determine the travel time. How does changing the amplitude affect the speed of the wave? Change the medium by stretching the spring to a different length. Determine the speed of a pulse in this new medium. How does changing the medium affect the speed of a wave?

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Guitar Waves

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Objectives

1. Analyze wave patterns of guitar notes, chords, and groups.
2. a. Relate wave characteristics to sound and wave shapes.
   b. Relate wave definitions to sounds heard and seen.
3. Illustrate how fixed end strings can vibrate in a number of modes.
4. Prove that the wave pattern of a vibrating string is the superposition of harmonics.
5. Discover factors that control the pitch of a vibrating string.
6. Measure and compare ratios of string lengths for harmonious notes.
7. Convert acoustical signals into electrical impulses electromagnetically. (Optional: Piezoelectrically.)
8. Optional: Observe and analyze wave patterns for processed signals.

Apparatus Needed

Cassette player, connecting cords (Coaxial one end with bare wires), Oscilloscope, long spring, "Duotone Guitars" (call for plan), cylindrical alnico magnets, copper coils or wire, Wave generator (Thornton), computer program on wave superposition, Video: "Donald in Mathemagicland".
Optional: These may be "solicited" from students: Acoustic guitar, electric guitar, small amplifier, various signal processors.

Recommended Strategy

1. Play a cassette of a dynamic rock guitar song into an oscilloscope (Heart: "Crazy On You", Led Zeppelin: "Ramble On", etc.)
2. Chart the relationships between wave characteristics (amplitude, wavelength, frequency, etc.) and what is heard and seen.
3. Run wave generator into speaker and oscilloscope to complete and reinforce this chart.
4. Illustrate standing wave harmonics with long spring.
5. Run computer program on superimposing standing waves to show resulting wave forms.
6. "Duotone" guitar experiment:
   a. Two-string "guitars" have one-meter long strings with metric tape from bridge to nut.
   b. Tune both strings to the same note on each guitar.
   c. "Fret" one string at various lengths to produce harmonious notes; record each length as a decimal.

   d. Create a "group" chord by using each guitar to play a separate note of the chord. Record these string lengths.
   e. Transform decimal ratios into simple fractions using a student-generated chart.
7. Show intro section of video "Donald in Mathemagicland" dealing with Pythagorean string length ratios to validate experiment.
8. Relate ratios to musical intervals.
9. a. Place magnets into copper coils to form a "pickup".
   b. Input ends of wire into oscilloscope and/or amplifier.
   c. Place pickup near a vibrating string and observe.
10. Optional activities:
   a. Illustrate musical moods with various guitar chord intervals.
   b. Observe sounds from different electric guitar pickups and relate to standing wave harmonics.
   c. Observe processed guitar signals to see and hear what is being done with the waves.
   *d. Run computer Fourier analysis on any of the above! (See Bill Blunk and/or Art Schmidt.)

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From Vibration To Sound

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Objectives:

1. To identify the parts of a sound wave.
2. To distinguish between a transverse wave and a compressional wave.
3. To describe how musical instruments produce sounds.

Apparatus Needed:

An overhead projector, plastic dish, glass, corks or stoppers of different sizes, tuning forks, rope, slinky, tin cans, string, paper clips, test tubes, test tube rack, student-made instruments, rubber tubing, 6 V cell and connecting wire, a jar of vacuum grease, electric vacuum pump and stand, bell jar and electric bell.

Recommended Strategy:

1. Discuss that sounds we hear are vibrations of molecules in air and other materials. They carry energy in waves that can be reflected, absorbed and transmitted like light waves, but cannot travel like light in a vacuum.

2. Place a large square, clear glass or plastic dish on an overhead projector. Fill the dish one third full of water. Drop corks or stoppers of different sizes into the center of the water and project the resulting wave motion onto a screen. Discuss what caused the waves and their characteristics. Now strike a tuning fork and touch the stem to the surface of the water. Observe the wave pattern produced. Discuss the cause of waves.

3. Tie one end of a rope to a doorknob. Produce transverse waves along the rope by shaking one end.

4. Use a long slinky-type spring to illustrate longitudinal and transverse waves.

5. Point out that wavelength can be measured from crest to crest, trough to trough, or any other two corresponding points.

6. Diagram a wave and label its wavelength and amplitude.

7. Relate sound to mechanical vibrations of all sorts. For example, a drum beat, the snap of a breaking stick, a truck rumbling by on a street. Discuss the vibration one can feel in the speaker of a stereo.

8. Explain the scientific meaning of "tuning in" a certain radio station (the adjusting of the circuit in a radio so that the circuit resonates electrically at the broadcasting frequency of the radio station).

9. Use student-made instruments to illustrate volume and pitch (one-string guitar, earharp, sandpaper blocks, paper tube kazoo, wind chimes, wood block tambourine, tongue depressor finger piano, garden hose recorder, etc.)

10. (IF AVAILABLE) Set up the demonstration of a bell in a vacuum. With the bell ringing, pump the air out of the bell jar, and then allow the air to fill the system again. Discuss why the sound of the bell gets fainter until no sound can be heard.

11. Prepare "learning stations" with independent activities related to the production of sound. For example:
A> Waves in a Coil Spring (To demonstrate a compressional wave)

B> Talking Through A String Telephone (To hear the transmission of sound)

C> Tuning Fork Sounds (To discover how pitch is related to the frequency of sound waves)

D> Test Tube Organ (To determine how the length of an air column affects the frequency of the sound)

12. As enrichment activities students could research the following:
1). Seismic waves transmit the energy of an earthquake. Research earthquakes to determine the types of waves made.
2). Traditionally, soldiers break step when crossing a bridge. In the 1800s a group of soldiers crossing a bridge in step set up a vibrational pattern that caused the collapse of the bridge. Research this incidental bit of history under the topic of bridges or vibrations.

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Comparison of Images Formed by Plane, Cylindrical (concave side), and Spherical (concave side) Mirrors

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Objectives:

1) To demonstrate that all mirrors reverse the image front to back, and that the apparent right to left reversal in a plane mirror is a result of this front to back reversal.

2) To describe plane, cylindrical, and concave mirrors in terms of curvature about horizontal and vertical axes.

3) To recognize that one's eyes lie along a horizontal axis, and one's forehead and chin lie along a vertical axis.

4) To help students recognize that right to left and top to bottom reversals occur simultaneously, and occur only in curved mirrors.

5) To discover that left to right reversals (and top to bottom reversal) occur when the axis of the object is parallel to the curved axis of the mirror, and that no left to right reversal occurs when the axis of the object is along a linear mirror axis.

Apparatus Needed:

Plane mirror, cylindrical mirror, concave mirror of short focal length. The cylindrical mirror can be made by gluing a piece of aluminized mylar inside a 120º section of carpet roll.

Recommended Strategy:

1) This exercise can be done anytime during the year as an attention grabber, or as an introduction to, or review of mirror images.

2) In order to avoid confusion which is associated with left and right in observing mirror images, it seems best to describe orientation along a horizontal axis in terms of some objects in the room such as the window side and door side.

3) Beginning with a plane mirror ask the students to observe the image of their left hand. Ask if the image is reversed left to right. Most will reply that it is. Then ask if the image is reversed to bottom. Point out the inconsistency of their answer and let them sit with that for a while.

4) Using a plane mirror ask the student to cover their eye which is on the wall side; ask them which eye is covered in the mirror (wall side

or window side.) Also ask if the image is reversed top to bottom. Direct the students to turn the mirror through 90º, make observations and answer the same questions.

5) Using the concave side of a cylindrical mirror, repeat No. 4 above, asking the same questions.

6) Using the concave side of a spherical mirror, repeat No. 4 above, asking the same questions.

7) Summarize student observations on the board, and help the class explain their observations.

8) Observations in a cylindrical mirror can be extended by viewing the image of two different colored arrows crossed at 90º. Ask the students to turn the object through 90º and observe what happens to the image. Ask them to turn the mirror through 90º and observe what happens to the image this time.

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Alternate Theory of Color Perception

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Objective:

To observe an alternative theory of color perception.

Apparatus needed:

A) Color wheel(s), wooden safety matches (for spindles), masking tape.

B) Black and white slide positives.

Procedure:

A) Activity - assemble color wheel(s) and spin; observe colors in daylight and under fluorescent light. Have students form a possible theory.

B) Land projections - two black and white slides (positives) are prepared and projected as outlined in "The Physics Teacher," March 1968, p. 129. Full color images, not possible with Newtonian theory, are produced.

Discussion:

Edwin Land's (of the Polaroid Land Corp.) "Retinex Theory" states that the eye processes black and white gray scales using three photoreceptors. Each photoreceptor processes the signals differently and then combines the processed information to produce colored images in the brain.

References:

Land, Edwin H. "Experiments in Color Vision," **Scientific American**, May 1959.
Land, Edwin H. "The Retinex," **American Scientist**, 52, 1964.

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Microscopes and Telescopes

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Objectives:

1. To use a knowledge of lenses to develop how microscopes and telescopes were first invented.
2. To apply ray diagrams to explain why these instruments work the way they do.

Apparatus Needed:

1. cheap magnifying glasses -- the kind given away at carnivals
2. various converging and diverging lenses
3. poster board, protractor, markers, and ruler for posters
4. cheap telescopes -- see #1
5. compound microscope and astronomical telescope (optional)

Recommended Strategy:

1. As a preliminary stage to my mini-teach, I drew posters containing the ray diagrams for converging lenses, converging mirrors, diverging lenses and mirrors, microscopes (simple and compound) and telescopes (astronomical, Galilean, and Newtonian). I explained that this lesson comes after the teaching of ray diagrams. I displayed my posters of the lens and mirror diagrams. Also, I showed the group an 'air' lens which consists of two watch glasses epoxied together to appear to be a converging lens. When the lens is immersed in water (phosphorine added for effect) and a light shown through the lens, the light actually diverges. This is due to a smaller index of refraction for air than water. Another neat idea is to use very large concave and convex mirrors to show student the pronounced difference in the two. Harry Hasegawa demonstrated using the large concave mirror to project a real image on a far wall.

2. To begin, give every student a cheap magnifying glass. Ask students to explain what it is and what it does. Students will be able to make real images of the classroom lights on their desks. Also, they will be able to magnify print, their finger, etc. Then most students will be able to say this is a converging lens. Refer to lens diagram for distant objects and objects closer than focal length. Ask students if there are other instruments which make objects appear larger. Most will say microscopes and telescopes. Then ask if the telescope actually makes the moon larger than it really is. To illustrate the optical principle that far away

objects look smaller than near objects, let students look out the window, place their hand palm up in front of them, and see if they can put a car in their palm. Then conclude that the telescope makes objects appear closer not larger.

3. Now let students 'play' with various combinations of lenses to form microscopes and telescopes. Pick a distant object to view (example: the wall clock). Also have books or typed papers to view. Let students 'play' for about 5 to 10 minutes with lenses and record their observations. Encourage them to find combinations that have erect and inverted images.

4. Use posters of ray diagrams to explain why certain lens combinations have different effects. Use posters of the microscopes and telescopes in your explanation. Also include tidbits of information on Anton Van Leeuwenhoek and Galileo Galilei and their ideas.

5. As an optional activity, have a compound microscope and a nice telescope for the students to look through and make some qualitative observations.

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Optical Illusions

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Objectives:

Given the introduction to optical illusions ,each student will be able to identify and construct four optical illusions illustrated in class.

Apparatus needed:

1. White cord string (medium)
2. Transparent sheets (4) 8"x10"
3. Overhead projector
4. Ultra violet light
5. Electric drill
6. 3 cardboard circles 12"in diameter
7. Assorted fluorescent paint
8. Felt pens designed to write on transparent sheets
9. Scissors
10. Straight edge (ruler)
11. Two 8"x 12" cards
12. Six (6) 3" screws; threaded with washers and bolts

Recommended strategy:

Optical illusions are deceptions of the mind. Sometimes these illusions are concerned with color, and sometimes with objects that are moving.

Constructing Optical Illusions Using Light.

Divide each of the three cardboard circles into four equal parts. Shade each of the sections on each cardboard with different colors using a different color fluorescent paint. Place small hole in center of each cardboard. Place 3" threaded screw through washer, place screw with washer through painted side of cardboard. Place washer on back of the cardboard and lock with bolt. Attach completed assembly to drill and lock in place. Stand in front of ultra violet light, turn off lights in room. Turn on drill and observe color patterns. Repeat above procedures for each of the remaining circle cardboards.

CAUTION: DO NOT LOOK DIRECTLY INTO THE ULTRA VIOLET LIGHT

Optical Illusions With Color

Take four(4) 12" sections of string and place each in a different color of fluorescent paint. Allow string to dry. Construct on the 12" x 24" cardboard using straight pins. Using the examples in the packet or examples given in chapter 6, construct several optical illusions of your choice .

Optical Illusions With Changeable Figures

Place several figures on the board taken from the packet of information or chapter 6 of reference book. Each student will duplicate each figure on the 8"x12" card. One can not duplicate with any degree of accuracy the optical illusions that will illustrate changeable figures on a computer. To obtain the optical illusions that will illustrate changeable figures, please contact Edgar Boyd at the school listed on this Mini-Teach Summary.

Referemce:

Beeler, Nelson F. and Branley, Franklyn M. Experiments in Optical Illusions, New York: Thomas Y. Crowell Co., 1951.

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Reflections With Mirrors

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Objectives:

Students will be able to define reflection.
Students will explain the laws of reflection.

Apparatus needed:

Four to five different texture surfaces, flashlight, paper, carbon paper, candles, pins, protractors, kaleidoscopes, coins, half gallon milk cartons, single edge blades, wood, rubber bands, 8x10 cardboard and two mirrors per student.

Recommended strategy:

Opening: flash a light beam on different surfaces to show reflection. Students read a handout with reverse writing using mirrors.

I. Students locate the image of a candle by means of parallax by placing a second candle behind the mirror and lining up the images.

II. Using pins in front of a mirror, students construct the incident ray, the reflected ray and the normal.

III. Locating image position by using angles of reflection. Students construct rays of reflection by sighting the image of a pin from the left and right sides of the pin. They then draw lines along the rays of reflection extending them beyond the mirror line until they cross.

IV. Students find the number of images reflected by two mirrors when placed at different angles.

V. A periscope is constructed using a half gallon milk carton, two mirrors, and a single edge blade.

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Color Mixing

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Objectives:

1. To distinguish mixing of colored pigments (inks, dyes) and mixing of colored beams of light.

2. List the three primary colored light beams, and recognize that these are the colors used in colored TV.

3. List the three primary pigments and recognize that these are used in color printing.

4. By use of the color wheel predict the color produced when either colored beams or pigments are mixed.

5. Demonstrate that shadows are produced by blocking (subtracting) light, and that the bright side of a shadow can be observed by using a plane mirror to block the beam.

6. Explain the formation of the colored shadows formed in overlapping colored light beams.

Apparatus:

Colored filters (red, blue, green; magenta, yellow, cyan), 3 filmstrip projectors, overhead projector, white paper screen, plane mirror, food packages, simple magnifiers, darkened or semi-darkened room.

Recommended Strategy:

1. Have students recall previous experience with color mixing. Ask what will happen when red and green crayons are mixed; what will happen when red and green filters are overlapped on an overhead projector. Do these; note similarity in results.

2. Ask what will happen when beams of red and green light are overlapped on a screen. The intensity of the light beams can be adjusted by blocking part of the lens. Students should realize that mixing colored pigments and mixing colored beams gives different results.

3. Have students predict the results of mixing red and blue beams, and mixing blue and green beams as above. Do it. Ask what will happen

when all three colors are mixed. Do it. From the results draw the color wheel on the board.

4. Students are familiar with mixing crayons. Ask how to make green when no green crayon is available. Point out that the red (magenta), blue (cyan), and yellow on the color wheel are the three pigments they are used to mixing. Show mixing of combinations of magenta, cyan and yellow filters on the overhead. From end flap of a food carton find the color of the inks used. Use a magnifying glass to observe that the picture is formed from the overlapping of colored dots.

5. This next part has to do with the formation of shadows formed by blocking the light from overlapping colored light beams. Overlap red and green beams; have a student hold a hand or some other opaque object in front of the screen. Try varying the distance from the screen. Ask students to explain how the various colored shadows are formed. If a mirror is used to block the light, the color of the light beams(s) that are being blocked can be shown. Try forming shadows when all three beams are overlapped.

6. Interesting shadows can be formed in overlapping red and white beams. The resulting green shadow is most evident if the beams overlap entirely and the intensity of the white beam is reduced. Try combinations of green and white, and blue and white beams.

Reference:

Phys. Teach. 22, **419 (1986) has a discussion of yellow light** produced from overlapping red and green beams.

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Comparison of Images Formed By Plane, Cylindrical (Concave Side), and Spherical (Concave Side) Mirrors

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Objectives:

1) To distinguish between horizontal and vertical axes and to recognize that ones eyes lie along a horizontal axis and ones forehead and chin lie along a vertical axis.
2) To describe plane, cylindrical, and concave mirrors in terms of curvature about horizontal and vertical axes.
3) To help students discover that image reversal occurs when the axis of the object is parallel to the axis of curvature of the mirror, and that no reversal occurs when the axis of the object is parallel to a linear mirror axis.

This exercise can be done:
1) Anytime during the year as an attention grabber and an exercise in observation and interpretation.
2) As an introduction to mirror images.
3) As a review of mirror images.

Apparatus needed:

Plane mirror, cylindrical mirror, short focal length concave mirror.

Notes: The cylindrical mirrors can be made by gluing a 10 cm by 10 cm piece of aluminized mylar inside of a 120º section of carpet roll tubing. In order to avoid confusion which is associated with left and right when observing mirror images, it seems best to describe orientation along the horizontal axis in terms of some objects in the room, such as window side and door side.

Recommended strategy:

1) Beginning with the plane mirror ask the student to cover one eye with their hand and observe the image of their face. Describe the image as reversed or not reversed top to bottom, or window side to door side. Turn the mirror through 90º and observe the image again.
2) Using the concave side of a cylindrical mirror repeat procedure no.1 asking the same questions.
3) Using the concave side of a spherical mirror repeat procedure no.1 asking the same questions.

4) Summarize student observations on the board and help the class explain their observations.
5) Observations in a cylindrical mirror can be extended by viewing the image of two different colored arrows crossed at 90º. Ask the students to turn the **object** through 90º and observe what happens to the image. Then ask the students to turn the **mirror** through 90º and observe what happens.

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LASER HOLOGRAPHY

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OBJECTIVES:

To make a Laser holograph and to understand why it works.

MATERIALS:

1 3-milliwatt Neon Helium Laser
3 rubber inner tubes (18 inch diameter) from a trailer
1 slab of marble (20 inches by 23 inches) possibly a tombstone
1 wooden sandbox (20 inches by 23 inches) filled with sand
1 -4mm focal length lens in a lens holder
1 -8mm focal length lens in a lens holder
1 white die to use as an object
1 object support
1 film holder consisting of 2 glass plates and 2 clips
1 white screen
1 black screen
non AH holographic film
green light
developer for holographic film
bucket and continuously running water
6 plastic clothespins with hooks
rubber gloves
2 wooden blocks, slightly smaller than the film holder
1 rubber squeegee, of the type window washers use

STRATEGIES:

The laser must first be turned on since at least fifteen minutes must be allowed to permit the laser sufficient time to warm up. During this time the frequency of the light is changing. Arrange the inner tubes on the table so that the marble slab may be securely balanced upon them. Place the sandbox securely upon the marble slab. Because of size constraints the lab will be set up on a diagonal inside the sandbox. Set the laser in the sandbox with the back in one corner and the light aimed at the diagonally opposite corner. Place the two lenses in front of the laser so that the light shines through the center of both. They must be as close as possible to each other without actually touching. Allow enough space between the laser and the nearer lens holder so that the black screen may be inserted or removed without jarring either. Place the object support in the corner diagonally opposite the laser with the object on it so that it is completely bathed in the light from the laser. At any time while the materials are being aligned in the sandbox the sand may be rearranged to facilitate their proper placement. Place the white screen in the film position directly in front of the object, between the object and the light. Focus the light so that the sharpest possible circle of light is displayed on the screen. Remove the white screen. Place the black screen between the laser and the near lens holder. **DO NOT TURN OFF THE LASER.** Open the film package and place the package, the pieces of the film holder, a plastic clothespin, and the opened container of developer where they may be conveniently found in the dark. Start the water running into the bucket. Turn on the green light and focus it on the sandbox. Make sure that all windows are completely covered. Turn off all of the lights except the green

light. Allow several minutes for your eyes to become accustomed to the dark. Take out one film and place it in the film holder. Press the film holder between 2
the wooden blocks to remove all air, which could cause movement of the film and ruin the holograph. Carefully place the film holder in front of the object in exactly the same spot where the white screen had been. There will be a mark in the sand. Carefully lift the black screen out of the sand, being sure that it still covers the light from the laser. Wait approximately one minute, so that all vibration in the sandbox ceases. Completely raise the black screen for two seconds, exposing the film, then lower the screen into the sand. Put on the rubber gloves. Take the film out of the holder, clip one corner with the clothespin, and place the film in the developer for one to two minutes. You may take the film out of the development solution to check on its progress. The film will darken as it develops. When the developing is completed, place the film in the bucket of water with the hook over the side. It should stay there approximately five minutes. Squeegee the film dry and a preliminary viewing may be taken by shining the laser through the film and viewing the holograph from the same side of the film as the laser. The object will appear to be behind the film, in its original location.

The image is formed when the light rays directly from the laser and the light rays bouncing off the object strike the film simultaneously, forming a pattern of constructive and destructive interference. The light coming through this interference pattern is viewed by the eye exactly as the eye would view the light bouncing off the original object. In addition, if one views the holograph from a different angle one will appear to be viewing the original object from that different angle. A green light is used because the holographic film, designed to be sensitive to the red laser light, appears not to recognize the wavelength of the green light.

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Computer Interfacing: Frequency Measurement - The Doppler Effect

John Bozovsky

Objective

To use computer interfacing to measure velocity using the Doppler Shift with sound.

Apparatus

The Apple IIe computer
The Frequency Meter program from Vernier Software
A microphone amplifier circuit using a schmidt trigger which I constructed from instructions supplied with the software.

Strategy

The microphone circuit will be set up to monitor frequency- clamped to a pole and facing outward. The computer program will be chosen to measure frequency and display it on the monitor in large print. Several devices can now be sounded within the proximity of the microphone--tuning forks, various musical instruments, etc.

A discussion will now be generated by asking the class for a method of measuring the speed of an object [or person] moving across the front of the room. It is expected that someone will soon suggest the direct measurement of displacement and time to be divided to give: v=d/t. A volunteer will now be asked to actually perform this movement while distance and time are measured using a meter stick and stopwatch. The formula will now be used to determine the speed v.

Now, a more exotic method will be suggested. A ball with a sounding Sonic Alert inside will be thrown back and forth among the class members. It will be noticed that a change in the frequency of sound is caused by the relative motion of the ball with respect to the listener: It will be noted that the frequency increases during the approach and decreases during the receding of the ball away from the listener. This change in frequency caused by relative motion is called the Doppler Effect which is demonstrated by the formula:

$$f = \frac{v}{v - v_s} f_s$$

f: the frequency detected by the listener

fs: the actual frequency produced by the source

v: the velocity of sound: [345 m/sec]

vs: the velocity of the source

Now for the action. Once again the volunteer will run across the front of the room but this time with a bell attached to him. While distance and time are directly measured to yield v=d/t as before, the computer will be instructed to measure the frequency it hears and to plot this data on a graph as the running person approaches the microphone. This frequency during approach is 'f' in the above formula. The bell is now held motionless directly in front of the microphone and the computer while it measures this frequency as 'fs'. All of this data [including the known speed of sound] can now be used to calculate 'vs', the speed of the runner and compare it with the direct result obtained from v=d/t.

THE MEASUREMENT OF IMPULSE
DURING A COLLISION

Objective

To use computer interfacing to determine the impulse during a collision.

2

Apparatus

Air Track and glider
The Apple IIe computer and a Pasco photogate
The Voltage Plotter program from Vernier Software
A voltage input unit
Bridge and amplifier circuits
Two strain gauges attached to a bar of spring steel
The instructions for the above circuitry are supplied along with the Voltage Plotter software

Strategy

An air track is set up with a single glider. The photogate is now set up at one end of the track. A beam of light is produced on one side of the photogate and is detected by a sensor on the other side of the device. The computer is set to measure the time duration of the eclipsing of the beam caused by the passage of the glider through the photogate. Knowledge of the length of the glider 'd' and this time of passage 't' can be used to determine the speed of the glider: v=d/t. If this value is multiplied by the mass of the glider, the result is the glider's momentum: p=mv.

By this time in the class, it will have been established that momentum is conserved. That is, the total momentum before a collision equals the total momentum after collision. But what happens to the momentum during the collision? [I could merely tell the students the answer to this question, but I wouldn't want to be too impulsive.]

Here is where the second interfacing device enters the demonstration. The strain gauge bar is mounted above the far end of the air track slightly beyond the position of the photogate. The glider is set in motion as before from the opposite end of the track, and is allowed to impact the strain gauge bar causing it to flex. This bending causes the two strain gauges mounted on the top and bottom of the bar to change resistance which is detected by the computer as a change in voltage. The computer program is calibrated to measure this flexing in terms of the force causing the bar to bend. The computer is now instructed to plot this changing force on a graph as a function of time. Force multiplied by time can now be determined as the area under the plotted curve. This relationship is known as the impulse=ft, and can be compared with the total change in momentum of the glider. Hopefully the results will show that the total momentum before collision equals the total impulse during collision which in turn equals the total momentum after the collision.

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The Pythagorean Puzzle

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Dedication: Thanks to Professor Harald Jensen (1898-1994), Physics Department, Lake Forest College, who originally worked this idea with the high school physics teachers at several summer institutes during the 1970s. This fine example of a phenomenological presentation would not exist if it were not for him.

Objectives:

For teachers (K - Phd): To model the phenomenological approach.

For students (grades 6 and above): To enable each student to prove the Pythagorean Theorem on his own.

For students (grades K - 5): To enable students to identify, name and/or define rectangle, square, triangle, and the concept of area (a measure of the amount of surface).

Materials Needed:

Pieces for Pythagorean puzzle sawed from colored, transparent plastic sheet (all the same thickness - about 1/8 inch - pieces of 4 different colors). Optionally - several $100 Grand candy bars.

Sandwich bags, one for each person, each bag containing a set of the puzzle pieces cut from brightly colored paper. (Use a machine to copy the puzzle onto sheets of yellow paper and cut out.)

Performance assessment rubric.

Strategy:

For teachers: Ask: "Who has seen this before; anyone? Raise your hands." If any hands are raised, then announce - "I need your help! If you have seen or done this before, please do not give it away to those who have not. Please don't spoil their fun."

Next, ask people to form pairs or partners by holding their hands up together. Tell them to remember who their partner is.

1. Have the overhead projector prepared ahead of time by placing a blank transparency centered on its projection area. Then begin by placing the pieces of the puzzle on the overhead and viewing the image on a screen so all can see and participate.

   Challenge teachers to tell you how to assemble the pieces into a solid rectangle using all the pieces - they must **tell** what to do; cannot show.

NOTE: Invariably, teachers - or almost anyone for that matter - will find it difficult to tell you what to do. e.g. They might say, "Move the piece on top next to the gray one." And you will move the piece, but not place them in contact; or you will move the wrong piece, etc. You will not automatically do what they **want** you to do, but rather only and literally what they **tell** you to do. They will laugh to see how "stupid" you seem to be, but they will see that you are doing only what they told you to do.

After 5 minutes or so, somebody might use the word "triangle" or "square" or "rectangle" to describe the piece they wish you to move. As soon as one of these words is used, repeat the word several times, (e.g. "triangle") and ask a volunteer to define the word. Ask them to name the other pieces and get their definition for each piece until everyone agrees and understands correctly the names of the pieces. For triangles, make sure everyone agrees to the meanings of "hypotenuse", "altitude", and "base".

This brings out the need for a common vocabulary, and the need to be able to express one's thoughts with precision. If, then, someone asks you to move a green triangle adjacent to the large, orange square, you will do so, but again, the result is not what the person intended for you to do. You then might ask, "Do you mean that you want me to move a green triangle so that its hypotenuse is in continuous contact with an entire side of the large orange square?" If they express agreement, then do it. Then see if others can express their thoughts with precision by telling you what to do next. But once the point is made, do not belabor it; go on to the next step.

2. Solve the puzzle.

See if they can direct you to the point where you have placed each of the four identical triangles so that each has its hypotenuse congruent with one of the four sides of the largest square, thus forming a **single, solid square.** Once this is done, solving the puzzle will proceed rapidly. But if more than 10 - 13 minutes have passed (aside from the digressions into the need for vocabulary, etc.) and they still haven't solved the puzzle (which is usually what happens), then pass out a sandwich bag of puzzle pieces to each pair.

Then challenge each pair to complete the puzzle to form a solid rectangle using their pieces. NOTE: If no pair succeeds within 5 minutes, then give a hint: Using the pieces on the overhead, show them how to form the **single, solid square** mentioned in the previous paragraph. Then let them take it from there with their paper puzzles. (See Sketch 1.)

The first pair to complete their puzzle should come up and show the rest of us how, using the plastic pieces already on the overhead projector. (After appropriate applause, etc. award them each a $100 Grand candy bar, which you have kept out of sight.)

Then say: Thanks! Now all pairs complete your puzzles!

Everyone complete? OK!

Now let's see how good you really are.

3. Can you arrange your puzzle to form two squares of equal area, using all

the pieces? (There is an alternate solution to the first part where there is an extra rectangle, in which case you omit the phrase 'using all of the pieces' - but, until they ask, do not tell them that they do not need to use one of the rectangles. See Sketch 2.)

Please do so now! (This will happen quickly for the pieces from sketch 1.) Then - ask a pair to show their solution using the puzzle pieces already on the overhead projector.

4. Say: You are now going to prove the Pythagorean theorem. Can anyone state what it is?

   After brief discussion, project a transparency of the Pythagorean theorem in words:

   For any right triangle, the square of the hypotenuse is equal to the sum of the squares of the two sides. In other words:

   If C is the length of the hypotenuse, and A is the length of its altitude and B is the length of its base, then $C^2 = A^2 + B^2$

5. The proof: With the two equal squares projected on the overhead for all to see, show that they have equal areas by laying them on top of each other. Make sure that the squares lie on the blank transparency. Now place them along side each other, and using a felt marker pen, draw an equal sign between them.

   Next, remove two of the four triangles from one square, and one the rectangles from the other. Show that the two triangles and the one rectangle have equal areas (superposition is one easy way). Since we have subtracted an equal amount of area from each of the originally equal squares, the remaining areas must be equal on the left and right sides of the equal sign.

   Again, remove two more triangles from one side of the equal sign, and a rectangle from the other side. Again, the remaining area on the left side must equal the area remaining on the right side.

   But on one side there will be a small square with the length of its side equal to the base of a triangle, and a mid-size square with the length of its side equal to the altitude of the same triangle. On the other side will be a single largest square with the length of its side equal to the hypotenuse of the same triangle. This is easily seen by placing the three squares on the three appropriate sides of any one of the triangles.

Performance Assessment:

1. Hand out 2 blank pages and a copy of the rubric to each pair of teachers.

   Say: I am going to ask each pair to use your puzzle to prove the Pythagorean theorem. Do you want me to take a few minutes to review it? (They will say yes.)

   OK - there are four steps: (Show them again.)
   1. left square area = right square area
   2. subtract equal areas from left and right
   3. repeat

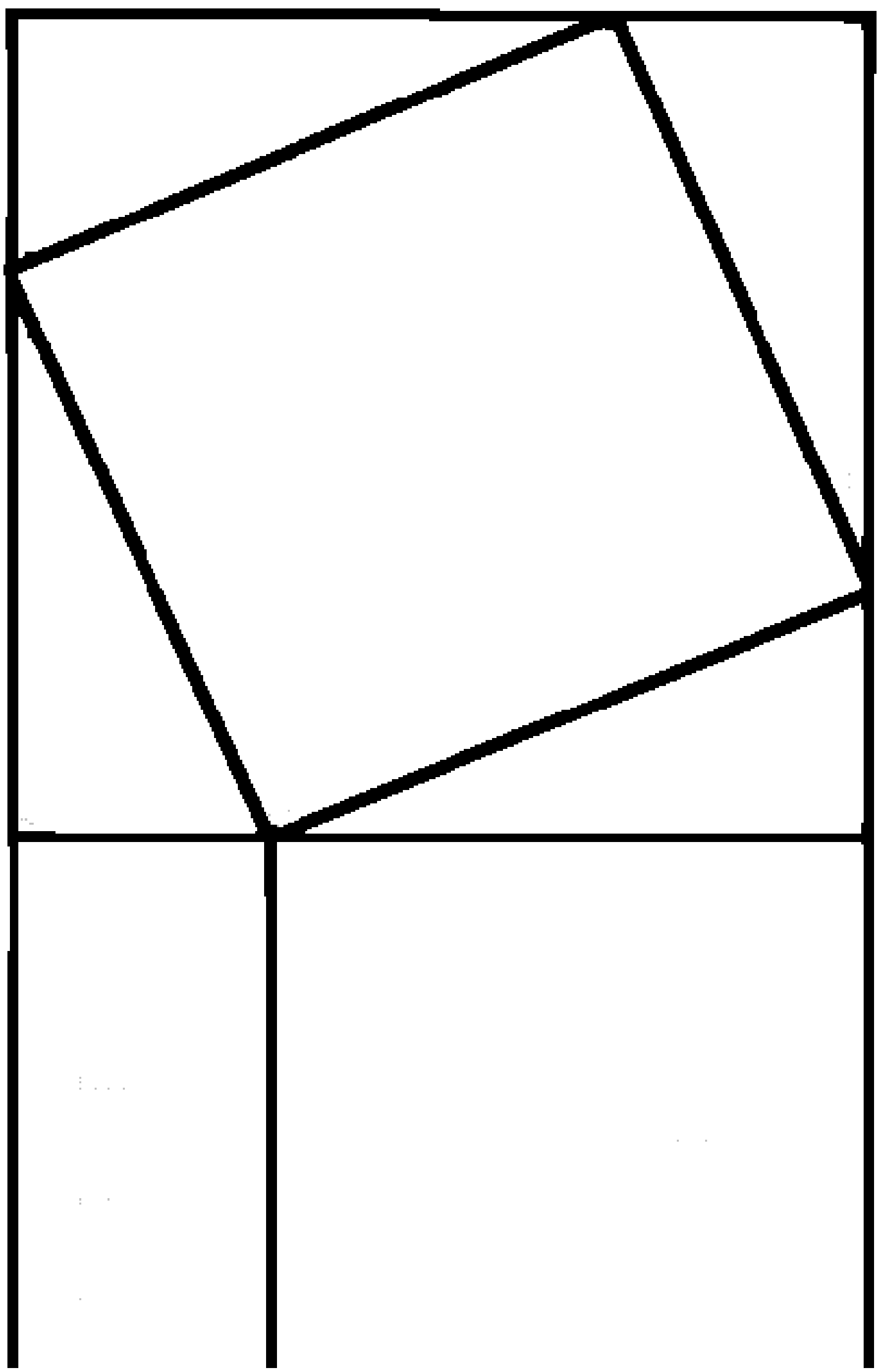
4. remainder areas are equal

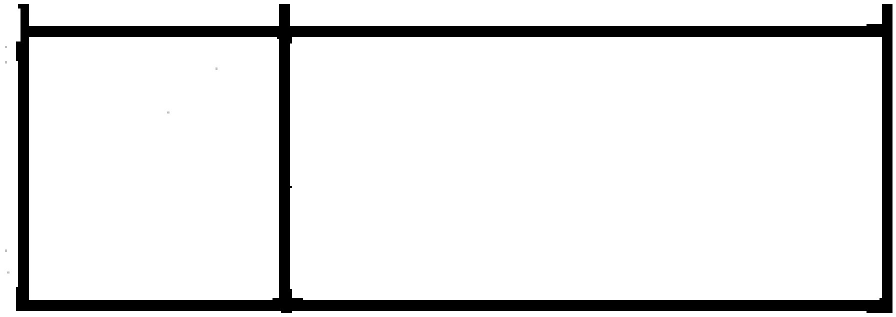
2. Now - each pair write up the proof on your page. Use rough sketches to show the four steps. You have about 7 minutes.

3. When finished, exchange your work with a neighboring pair and use the rubric to score each others work.

References:

If the following graphic does not display or print, contact the author by letter, telephone or email. NOTE: the puzzle should be scaled so that the diagonal square is 3 inches on a side.





Sketch 1

In order to draw the puzzle on your own, use 2 sheets of 8.5 x 11 paper, a pencil, a ruler, a straight edge and a scissors.

Draw a square three inches on a side. (This is easily done by starting at one corner of one of the papers and measuring 3 inches down each edge.) Cut out the square.

Place the square so that its edges lie along the bottom right corner edges of the second sheet of paper. Now raise and tilt the square so that its right bottom corner has moved up the right edge of the page by about 1.5 inches; its left bottom corner should lie at the bottom edge of the page, about 2.5 inches from the right bottom corner of the page. The now tilted bottom of the square will be the hypotenuse of a right triangle, and the right bottom edges of the page will be the altitude and base of the triangle. Use some tape to hold the square in place on the sheet.

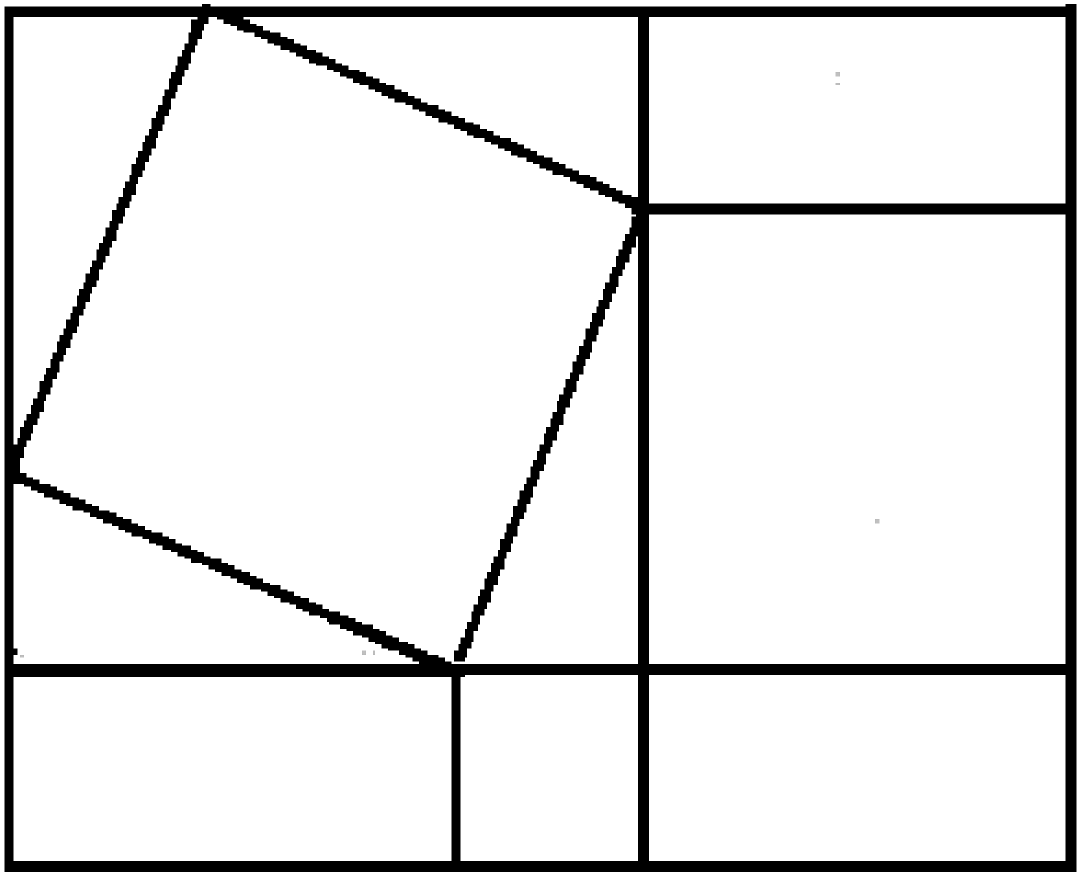
Next, draw a horizontal line across the page so that it passes through the top-most corner of the tilted square. Then draw a vertical line so that it passes through the left-most corner of the tilted square. The square will now be circumscribed within a larger square formed by the horizontal and vertical lines drawn on the sheet. This also leaves the original tilted square surrounded by four identical triangles; the hypotenuses of the triangles are the four sides of the tilted square.

For the upper-left triangle, draw a square using one of the triangles sides as one side of the square. Draw another square using the other side of the triangle.

Now draw vertical lines through the vertical sides of the smallest square (on the left of the triangle).
Then draw horizontal lines through the horizontal sides of the mid-size square (on the top of the triangle).

You should now have formed three identical rectangles with long sides vertical (and equal in length to the altitude of the triangles), and short sides horizontal (and equal in length to the base of the triangles).

Your puzzle is now complete. Cut it out and play with it. Enjoy!



Sketch 2
(an 'extra' piece for the second part)

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Mathematics/Physics**.**

Identify And Construct A Constellation

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-

Objective(s):

The student will identify and construct a constellation.

This lesson is designed for students in the 3rd grade.

Materials:

1. Shoebox, scissors, box cutter, flashlight and batteries, glue, tape, stapler, black construction paper, sharpened pencil or nail, newspaper.

- Select a constellation.
- Label the sides of the shoe box a, b, c, d, (a should be opposite b).
- On the side labeled ‘a’ cut an opening for the flashlight (it should fit snuggly).
- On the side labeled ‘b’ cut out a rectangular shape (size to be determined by the size of the shoe box)
- Secure the top of the shoebox (after openings have been cut).
- Cut a piece of construction paper to cover the opening on side ‘b’
- Place the constellation pattern on top of the construction paper.
- With the pencil (or other sharp object) punch out the star pattern.
- Remove the constellation pattern.
- Place and secure the construction paper
- Slip the flashlight through the opening in side ‘a’ turn it on.
- Point side ‘a’ to a wall in a darkened room.
- Try to identify the constellation of a classmate.

2. Paper cup, scissors, box cutter, flashlight and batteries, glue, tape, stapler, black construction paper, sharpened pencil or nail, newspaper.

- Select a constellation.
- Cut off bottom of paper cup.
- Place the constellation pattern on top of the construction paper.
- With the pencil point (or other sharp object) punch out the star pattern.
- Remove the constellation pattern.
- Place and secure the construction paper to the top of the cup.
- Slip the flashlight through the bottom opening of the cup.
- Turn on the flashlight.
- Point the top of the cup to a wall in a darkened room.

3. Transparent paper, glow in the dark glue or paint.

- Select a constellation.
- Place the constellation pattern under a sheet of transparent paper.
- Put a dot of paint or glue at each star point of the constellation.
- Remove the constellation pattern.
- Hold up the transparent paper.
- Turn off the lights.
- Constellation will glow in the dark.

Strategy:

-

Tell the student to choose which method he will use to make a constellation, shoebox, paper cup or transparent paper.

By completing this activity, the student will be able to name, one or more of the constellations.

Conclusion:

After the students have completed the lesson on the constellations and the related activity. The teach will give a quiz on related vocabulary and pictures of the constellations for the students to identify.

Mikail A. Siddiq - Raymond School

Simple Machines make work easier.

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Objective(s):

My objective are to show that through the use of simple machines work can be made easier.

Materials Needed:

A board about one (1) meter long and a triangular block of wood.
A pencil sharpener, a long piece of string and a few books.
A single fixed pulley with a string or cord.
A few meter sticks about six.
A compass rose.

Strategy:

First to show that lifting things or books manually requires more force than lifting through the use of simply machines.
Finally to measure the displacement, velocity and attempt to measure the amount of force used.

Performance Assessment:

Describe the operation of a lever. State that a lever can be used to change the direction of a force.
Describe how a wheel and axle machine makes works easier. Explain that force is gained when effort is applied to the wheel of a wheel and axle machine.
Identify two wheel and axle machines.

Conclusions:

Classify simple machines as a lever, pulley, wheel or axle.

References:

Physics: Its Methods And Meanings by Alexander Taffel, Ph.D.

Motion and Force: Practically all of the changes we see in the world about us are the result of motion. (Force: A force means simply a push, pull, or a lift.) A force is being used to change the state from rest to motion.
Motion is controlled or changed by means of force.
Motion: is movement. Uniform Motion: is both the speed and direction of the moving body remaining the same. It is therefore motion at a constant velocity. Accelerated Motion: is motion with changing velocity (speeding up), the rate at which its speed is changing.

Displacement is a Vector: Motion generally involves a change of position of the object being moved. A change of position is called a displacement. To state exactly how the position of the body changed, we must also state in what direction it was moved.

Quantities such as displacement are called Vectors. A vector is characterized by the fact that it has both a magnitude or size and a direction. Quantities having only magnitude, such as the mass or length of an object are called Scalars.

Velocity and Force are Vectors: Two other important vectors related to the study of motion are Velocity, and Force. To tell exactly how an object is moving at a given moment, we give it velocity. By velocity we mean not only speed of a body but also the direction in which it is moving. Thus, velocity is a vector whose magnitude is the speed of the body and whose direction is the direction of motion of the body.

It is evident that a force is a vector, since the effect a force has on a body depends not only on the size of the force but also on the direction in which it acts. Therefore,in describing any force, we must tell not only its magnitude but also its direction.

Representing a Vector:A vector is represented by an arrow drawn to some selected scale. The length of the arrow shows the magnitude of the vector. The direction of the arrowhead shows the direction of the vector. To represent a displacement to the north of four meters, we first select a scale which, in this case, we take as one centimeter =one meter. Now we draw a north - south line four centimeters long to represent four meters. Finally, we put an arrowhead on top of this line to show the direction of the displacement.

Energy: is the ability to do work.

Kinetic Energy: We mean the energy that A body has because of its motion. Any moving body has kinetic energy because it is able to do work by moving other bodies.

M=Mass, d=Distance, F=Constant Force: The work done by the force is (Fxd). If (a)=is the acceleration produced by F, then F=Ma. It follows that the work done is: Fd=Mad: For a body that starts from rest and is accelerated at a constant rate a, the speed acquired by the body after traveling a distance (d) is given by (V^2=2ad) whence,

$$ad=(V^2)/2$$

Substituting this value of (ad)in (Fd)=Mad, we have:

Fd=(MV^2)/2: This quantity is defined as the kinetic energy KE of the body

$KE=1/2MV^2$

Potential Energy: A body possesses energy in a stored form that is not readily noticeable and is called potential. We may define potential energy as the ability of a body to do work because of the relative position of its parts or because of its position with respect to other bodies.

To compute the gravitational potential energy that a body has over a selected base level, we simply compute the work needed to raise it from the base level to its actual position. For bodies near the surface, this work is equal to the surface, this work is equal to the weight of the body (w) times the height it was lifted (h).

Therefore:

Potential Energy =w x h
and since w=Mg
PE =Mgh

Questions for the class:
(1). Describe the operation of a lever.
(2). Describe how a wheel and axle machine makes work easier.
(3). Classify simple machines as a lever, pulley, or wheel and axle machine.
(4). Also in each example of a lever, pulley, or wheel and axle machine, tell whether we are using displacement, velocity, or force or a combination of each.

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Kimberly Baker - Marquette East

Moon Phases

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Objective(s):

A moon phase chart is an easy way to illustrate the waxing and waning of the moon. Students can discover why the moon isn't visible. They also come to understand why varying locations warrant different phases.

This lesson is designed for second grade, but may be used for upper grades as well.

Materials Needed:

One large poster board
One medium - large size ball
An overhead projector
30 paper circles about 8cm in diameter, made from black construction paper
A calendar with dates of the new moon, 1st quarter, full moon and the 4th quarter
White chalk

Strategy:

1. Make a chart to show the phases of the moon.
2. Use black circles (8cm in diameter) to show the thirty phases of the moon.
3. Use white chalk to show the white portions of the moon phases. For example:
4. Paste or tape the various moon phases in order on the large poster board.
5. Number and label each card, under each moon phase, in the following order: 1 - New moon; 2 - New Crescent; 3 - Crescent; 4 - Crescent; 5 - Crescent; 6 - Crescent; 7 - Crescent; 8 - First Quarter; 9 - Gibbous; 10 - Gibbous; 11 - Gibbous; 12 - Gibbous; 13 - Gibbous; 14 - Gibbous; 15 - Full Moon; 16 - Gibbous; 17 - Gibbous; 18 - Gibbous; 19 - Gibbous; 20 - Gibbous; 21 - Gibbous; 22 - Gibbous; 23 - Last Quarter; 24 - Crescent; 25 - Crescent; 26 - Crescent; 27 - Crescent; 28 - Crescent; 29 - Crescent; 30 - Old Crescent.

Performance Assessment:

1. Have students circle the projector and ball. As the students circle, the ball's crescent grows from First Quarter to First Gibbous, it becomes obvious to them that the Moon's change is gradual rather than a jump from one phase to the next as pictured on some calendars.

(Of course, since each child is in a slightly different location with respect to the ball (Moon) at any given moment, each is seeing a different phase.)

2. Students may also be assessed while having fun with musical moon positions. Chairs are optional. Music should be used. While students slowly circle the moon (ball in front of overhead projector), call stop, then ask students to identify the phase they see.

   (This demonstration actually shows the phase changes of an inferior planet rather than the Moon; it is not intended to be accurate, only to show phases.)

3. To be sure that students have grasped the pattern of moon phases, refer to a calendar for the current moon phase and have each student, on a blank calendar, draw moon phases accordingly. Students can check their accuracy each night by watching the moon.

   (Again, warn students that, because each child is in a slightly different location with respect to the Moon, each is seeing a slightly different phase.)

4. Have students chart the phases from their calendars on the board. Start with the more significant phases first, ie New Moon, 1st qtr., Full Moon, etc... Next, fill in all of the other phases. Be sure to inform students on whether white shading will represent the lightness or darkness of the moon in its phase!

Conclusions:

A moon phase chart is an easy way to illustrate the waxing and waning of the moon. Children who follow a phase on the moon chart each morning will not grow up thinking that the moon has only four phases and will be in a better position to understand other gradational processes in nature.

References:

Science and Children. May 1982, Vol. 19, No. 8

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Lilla E. Green - Hartigan Community Arts Specialty School

Let's Outrage The Bull

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Objective(s):

This lesson is designed for grades Kindergarten - 8th, for a thirty-five minute, once-a-week science lab period. The main objective of this Mini-teach is to:

(K - 2) understand principles of energy - kinetic energy vs. potential energy
(3 - 5) construct a model roller coaster and demonstrate kinetic energy and potential energy
(6 - 8) design and explain how a model roller coaster uses acceleration, momentum, gravity and principles of potential and kinetic energy

All pupils will be able to relate these principles to everyday life. They will also be able to understand the effects of weight and speed in regards to momentum.

Materials Needed:

These materials are designed for groups of four - five pupils, in the intermediate - upper grades. The Kindergarten - 2nd grade teacher should demonstrate the construction of the model roller coaster, eliciting suggestions from their pupils, in regards to the design of the class roller coaster model.

Each group needs:

12 - 15 ft. of pipe foam insulation
3 - 4 marbles
duct tape / masking tape
model roller coaster

overhead projector
videoclip of "Roller Coasters"
VCR

*optional

* 4-5 12" x 12" tagboard squares
* a chair, or table

Vocabulary list: gravity, friction, energy, kinetic energy, potential energy, momentum, acceleration, laws of motion, Isaac Newton

Strategy:

1) View a three - minute video clip of Nova's "Roller Coasters" or Bill Kurtis' New Explorer's "Physics At the Amusement Park."
2) State the problem the pupils need to explore and have a model of the roller coaster on the blackboard or overhead projector.

Problem: How can I design a thrilling roller coaster ride that stays on track? (For K - 2, have a model roller coaster on the demonstration table. Have pupils volunteer to demonstrate changes they'd like to make in the teacher-made model).

3) Pupils will share their hypotheses (guesses) of the problem.
4) Give each group the materials and assign them the problem of proving that their design is the best, most thrilling ride. Their ride must include at least one loop in the design, and it must stay on the track.
5) Have the pupils show where the marble has potential energy, kinetic energy, where it accelerates and where gravity keeps the roller coaster on track. Their explanation needs to be clear - both to the class and on their group report.
6) They must describe their winning design to the class.

Performance Assessment:

In Kindergarten - 2, pupils will draw the roller coaster, and use arrows to show the marble's trail from start to finish. They will write a sentence that shows they understand that the higher you start off........ the farther your marble will roll before stopping.

With grades 3 - 8, observe how pupils work together. Note whether they put side motion to their track design. This shows they understand how to develop momentum and acceleration. Have pupils share orally and visually with the entire class. They must summarize their results, using their definitions of the principles of gravity, acceleration, potential and kinetic energy and the laws of motion.

Conclusions:

Pupils conclude that the higher the inclined plane is (the place where the marble begins its descent), the more energy can be stored. Their winning diagrams pinpoint potential energy, kinetic energy, gravity and acceleration. All pupils should understand that potential energy is at the start of the first hill, and acceleration and momentum begin at the bottom of the hill. Kinetic energy carries the marble through its course of loops, but as it runs out of energy, it slows to a stop. This is an informal assessment which measures group collaboration and social behavior as well as their comprehension of vocabulary terms.

References:

Scholastic, Inc.

Internet:
www.pen.k12.va/us/Anthology/Pav/Science/Physics/book/Simplecoaster/home.html

An "AskEric Lesson Plan" - Downhill Discoveries, by Marty Stallings

*email me at lil1017@aol.com for the pupil worksheet in the Scientific Method format

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Lyvonia Hearns - Asa Philip Randolph

Building A Straw Power Tower

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Objective(s):

To explore the effects of shape, materials, and balance in building a Straw Power Tower that can support the most pennies. Towers must be at least 58cm (23in.) tall. This activity is for students in grades 2-8. Divide the class into teams of 5 or less.

Materials Needed:

Per Team

Lab Report	Contest Rules	50 Glad straight straws
hole punch	many pennies	120 small metal paper clips
2 large paper clips	scissors	5 clean, empty 1-pint milk or juice cartons
measuring stick	table, desk, or floor	

Strategy:

Set aside 15 straws from the 50 you were given. With your team begin to build a Tower from your straws and paper clips. It can be any shape you want, but you can't use any other materials. Stop building when your 15 straw tower stands up by itself. Make a Weight Basket out of the 1-pint milk carton. Use the large paper clips to attach the weight basket to the tower. The Basket must not touch the ground or floor. Slowly add 20 pennies to your Weight Basket. Where does your tower sag or bend? If you need to, add more pennies or jiggle the basket. Could these weak spots collapse under more weight? Remove your Weight Basket.

List Your Variables

Pick one weak spot on your Tower. What change could make the weak spot sturdier? Anything you could change on your Tower is a variable. Now with your team make a list of changes that might improve your Tower in general. Some variables to think about are:

Shape- Could you make a square or polygon (many sided shape) into triangles to make it stronger?

Strength- of beams- Could you combine 2 or more straws to make a beam stronger?

Length of straws- Could some beams be longer? Should some be shorter (cut straws)

Joints- Are there other ways to connect the straws?

Locations of strong beams- Should the strongest beams be near the top of the tower or the bottom?

Size of foundation (base)- What effect does changing the size of the foundation have on your Tower?

Location of Weight Basket- Does it matter where you attach the Weight Basket? (The bottom must be at least 20cm (8in) off the ground.)

MAKE A CHANGE

Choose one variable from your list. Make the change to a weak spot on your Tower. Make one change at a time. (For ex., if you change to longer beams, don't also change the size of the foundation.) Why is it important to change only one variable at a time? Record the variable you changed on your lab report next to "15-Straw Tower" Now test your change. Attach the Weight Basket to the exact same spot as before. Add 20 pennies and observe your Tower. Did the change make the weak spot sturdier? Record the results.

Keep Building

Set aside 15 more straws from your 50. Continue to build and strengthen your Tower. After these 15 straws have been added, test your Tower with a Strength Test as before. Then change one variable that could make the weak spot stronger. Add the last 20 straws to your Tower. Repeat the Strength Test. Make the final changes until your team is satisfied with your Tower's strength, shape, weight Basket attachment, and height.

Performance Assessment:

Name your Tower. Measure, record, and sign off its official height on your lab report. Gently add pennies to the Weight Basket, counting one by one. How many can the Tower support before the Weight Basket hits the table? Enter your penny count on your lab report. Now write a paragraph on the back of your lab report. List the features that made your Power Tower strong, explaining how each helped the Tower's weak points. Describe your Tower's weak points. What made it finally collapse?

Conclusions:

Display your Straw Power Towers around your classroom. ENJOY!

References:

Super Science Nov./Dec. 1998

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Mathematics/Physics

10 Cheap or Free Science Tips

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Objective(s):

To give the science and math teacher some classroom tips and/or hints that can be useful while being either free or inexpensive.

Materials and Strategy:

1. To erase permanent marker from smooth, non-porous surfaces go over the permanent marker with erasable marker and then erase all of the marks.
2. To photocopy blue ditto sheets put a transparent sheet of yellow plastic between the ditto and the copier. The clear yellow makes the blue print 'look' black to the copier.
3. To keep your NiCd cell phone battery working for a long time, run it down on a regular basis. Call some number that you know will not answer and let it ring until the phone shuts itself off and then recharge it. Do this about once a month and it will last many years. (I call the school late at night and, if someone answers, hang up and call the police.)
4. To get a **REALLY BIG** funnel and clear beaker, get a 5 gallon bottled water bottle and use a saw to cut the top off. Most bottles water companies will not sell or give away their bottles but many companies that have bottled water will give you the empty bottle if you tell them what you want it for and promise to not tell where you got it.
5. To get free bowling balls go to the nearest bowling alley and ask for chipped or damaged balls. Generally they will give some to you free.
6. To get a bowling ball that will float in water, get a ball with a weight of 11 pounds or less. Bowling balls with a weight greater than 12 pounds will sink.
7. To make a cheap Cartesian diver, use soy sauce or ketchup packets from a fast food place. You do need to sort through them to find the ones that just barely float but about half of them work.
8. For a cheap tornado bottle connector use PVC pipe cut into about 1" lengths. Using two – 2 Liter bottle caps, epoxy them into the pipe to form the connector. To make it easier to epoxy together, drill a small hole in one of the tops, rough up the inside of the pipe and the outside of each of the caps. The hole allows excess epoxy to seep out and the roughness gives the epoxy a good grip. After the epoxy is thoroughly set, drill a 3/8" hole through their centers to form the passage. Ten feet (enough for about 120 connectors) of PVC pipe costs about $1 in the Chicago area, meaning that you can make connectors for most of your students.
9. To annoy the reminder of the faculty, have your students make a 'turkey clucker'. Using a plastic cup, poke a small hole in the bottom, run a COTTON string through that hole and tie the inside end of the string to a toothpick. Wet the string and stroke it with another piece of cotton.

10. Another way to annoy the rest of the school is to get an aluminum rod about ½" to ¾" in diameter and 3’ to 5’ long. Drop the rod on a tile or wood floor.
11. Make a cheap accelerometer from a plastic peanut butter jar. Poke a small hole in the inner liner of the top and tie a knot in a string and pass it through the hole. On the other end of the string tie a cork or styrofoam ball so it does not quite touch the bottom. Submerge the jar in water and then put the lid on tightly. When the jar is held inverted, the cork or styrofoam ball will stretch the string and float toward the ‘top’ (bottom?) of the jar. Moving rapidly will cause the cork or ball to move in the direction of the acceleration.

Physics at the Zoo

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Objective:

The idea is to try to answer some physics questions at the zoo. The teacher can adjust the level of these questions to almost any grade, or just skip questions that are inappropriate. No materials or apparatus is necessary. We used Lincoln Park Zoo in Chicago.

1. Sizes

Animals are physically designed by evolution to function well. Compare the width of the legs of large heavy animals with the width of a similar small animal. Which animals did you compare and what did you find out?

Now compare faster and slower animals, and see how the legs compare to the body. Which animals did you choose, and what did you find out?

Now compare the weight of an animal with the weight of food consumed each day. Food is necessary for energy, and that energy is mostly used to produce heat and keep the body warm. Heat is lost from the surface, and small animals lose heat more rapidly because they have more surface compared to their weight. (Divide the surface area by the weight to calculate the factor). Compare the animals you have chosen here.

2. Center of Gravity

Look at various animals and estimate where their center of gravity (or balancing point) is. If the center of gravity is not supported by the animal's legs, the animal will fall over. Look at a giraffe, a peacock, an elephant, and a large deer. How do these animals support their center of gravity when they walk and lift a leg or two off the ground? Tell what animals you watched and what you observed.

Look at a pregnant animal and then look at a pregnant woman. How does being pregnant change how they walk? Think about the center of gravity.

3. Estimation

Estimate the weight of various animals, and then look at the plaques and see if they tell you the answer. Which animals did you choose, and how close was your guess? Many people estimate far too high for the American Eagle. Ask the zoo personnel how much an eagle weighs.

4. How Animals Travel

Every animal has to "push off" or exert a force in order to move. Think of snakes and birds. What do they push against? How many hooves are on the ground when a deer pushes off? What did you observe?

Sketch a distance time graph for a monkey or a snake.

5. Archimedes Principle (or Sinking and Floating)

How do turtles, snakes, or Polar bears sink and then rise again?

6. Paddle Boat

There are paddle boats for rent in the lagoon by the restaurant. How much do they sink when a person walks into them? What do they push against?

Estimate how fast you can go in the boat, and compare that with how fast you can walk. Why does the boat float if it is made of metal?

7. Light in the Water

Find one of the tanks where you can see a bear or seal swimming under water. Look up at the surface. Can you see out, or do you see a reflection? Is your vision distorted when you look directly into the tank? How far can you see?

8. How Do Animals Fall?

Look at the monkey and the flying squirrel. How do they use the air to affect their fall? How does a bird do it?

9. Sound

Which animals have the highest and lowest pitched sounds? What about bats? How do they produce such a high pitched sound? Why are sounds under water dangerous to the animals? (So you shouldn't tap on the glass!)

10. Do One Yourself

I hope my questions gave you paws. Now it's your turn. Think about your presentation this summer. Where did you see an application of your lesson at the zoo today?

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Shop projects Summer Smile Program

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Objective:

This is a listing of the projects that the teachers made in the shop proportion of the Smile Program. This is intended to be a guide as to the type and the different projects teachers can built in a shop class. This is not intended to be a complete list but rather a guide for future classes. The projects are intended to be used in the classroom and teachers are not restricted to this list.

large bird	22	Towers of Hanoi	71	Triangle Puzzle	94
hall pass	19	Small bird	39	wine bottle holder	46
Jensen bar	52	wave bottle	39	conductivity testers	28
plant dolly	8	tile for bases	6	tiles for centripetal	12
hex-a-flex	8	green house	6	bed of nails	5
mystery box	4	'T' square puzzle	6	white board 4x8 sheets	20
teddy bear	1	frame a picture	1	trading card stand	1
nail puzzle	2	air tunnel	1	test tube holder	2
planter	1	anerometer	1	barometer	1
rain gauge	1	bed of nails	5	static charge collector	14
circuit board	1	pulley holder	1	dicot model	1
clock	1	hovercraft	2	belt holder	3
rocket launch	2	nail sculptor	2	quiz board	1
track & rails	1	mitochondrion	1	cell and nucleus model	1
hair follicle	1	arteries model	1	skin + layers model	1
cell & membrane	1				

total projects = 508 in 1996

The above is a list of the projects that were done in the summer of 1996. You are not restricted to this list, these are only suggestions. One project must be something that you will use in the classroom. The second project may be of your choice. You must do 2 shop projects. Three are recommended. If you choose to do a classroom set you must furnish your own materials. The first one is free in most cases. You will be asked for an accounting at the end of the 5 weeks.

The following materials are needed from home if you wish to do some of our projects. 1 three litre bottle, 2 two litre bottles, 1 one litre bottle, 6 20oz bottles, all bottles must be clear.

Materials available for use in shop:

The following tools are located in the student shop in the basement of Seigel Hall. Drill Press, Sander, Band Saw, hammers, saws of various types, pliers, screw drivers, gauges, wrenches, files, clamps, etc. Materials which are in the shop for the teacher's use include assorted wood, plywood, 1 x 2, 1 x 4, 1 x 6, plastics, screws, nails, glue, glue guns, tape, string, and other assorted materials for building classroom projects.

Shop rules: **Safety, Safety, Safety, Safety, Safety, Safety, Safety, Safety**
Please use common sense when in the shop. The University's policy requires all participants to wear glasses when working in the lab or shop. This policy will be enforced. Please avoid loose clothing, be careful of rings, or jewelry. (See detail list at end of report.)

New projects 1997:

string art	accelerometers	centripetal apparatus
cars	electrostatic board	catenary curve apparatus
bird in cage	whale clip	Pythagorean Theorem Puzzle
tornado bottle	student book holder	set of conduit pipes
motor + battery	scissors holder	kaleidoscope
rocket launcher	skate board	large book holder
book shelves	book ends	mole of plastic
bed of nails	music pipes (PVC)	music triangle (Al)
dry marker holder	flower color board	belt holder
small book holder	interference speakers	molar volume 22.4 L
clock telling time	wooden flowers	apple displays

Resources:

Resource Center
222 E. 135 Place
Chicago IL 60627
773-821-1352

Creative Reuse Warehouse
721 W. O'Brien
2 blocks South of Roosevelt
between the Dan Ryan and
Halsted street. Hours Tue., Thur., & Sat. 9am-5pm
312-421-3640 Sunday noon - 4 pm

America Science and Surplus Center
3605 Howard Street
Skokie IL 60076

Stores in Chicago, Geneva, Milwaukee and Orland Park

Policies and Procedures for use of Student Machine Shop:

1. No unauthorized person shall use the Student Shop.
2. Authorized persons are those who have taken the shop training course and/or who have been approved by the Student Machine Shop Supervisors.
3. You are not to use the machines in the shop until you have been given appropriate safety instructions by the supervisor.
4. All safety guards must be kept in position while machines are being operated. Safety goggles or glasses are required at all times.
5. Machines are not to be operated while the instructor is out of the room.

6. All adjustments are to be checked and secured before the power is turned on.
7. Remove all wrenches and other tools from the machine before turning the power on.
8. Machines must come to a dead stop before any required adjustments are made. It is a good idea to unplug the machine before working on it.
9. Have the instructor check any special or unfamiliar set-ups before turning the machine on.
10. Make sure loose clothing, jewelry, hair, etc is fastened securely or removed before operating a machine.
11. Students who are not operating a machine should stay clear. If not specified stay at least 3.3 ft or 1 metre away.
12. Do not distract the attention of the machine operator. If operating a machine, concentrate on your work.
13. Pick up the scrap pieces. Throw away the small pieces and put the larger pieces under the storage bench or in a designed place.
14. Shut the power off when you are finished or if you are leaving the machine, never leave the machine running unattended.
15. Use extreme care that all lumber is free from nails, bolts, metal or loose knots before machining.
16. Materials should never be fed into a machine faster than it will cut or sand.
17. "HORSEPLAY" is absolutely forbidden in the shop or lab.
18. Some jobs require a helper. This requires great care on the part of both people.
19. Never perform any operation unless you are entirely sure as to how to perform it properly and safely. Make use of a dry run or practice run.
20. If you notice anything wrong with a machine or something goes wrong with a machine, shut it down and notify the instructor.
21. Report any injury to your instructor immediately, if after hours report to the campus police.
22. Any breakage of tools, bits, blades shall be reported immediately to your shop supervisor.
23. Special tools may be used outside of the Student Shop and must be signed out on the sheet provided by the door. Ordinary tools such as screwdrivers and wrenches may not be taken out of the Student Shop. No tools are to be signed out on an indefinite loan.
24. All tools are to be returned to their proper place when you are finished using them. Do not leave bits in the drill press or lathe.
25. Clean up your area after using the shop, do not leave a mess for someone else to clean up, it is your responsibility to clean up after yourself. Place all waste in the proper containers.
26. The Student Shop Supervisors shall have the authority to alter these policies and procedures.
27. Raw materials in the shop generally belong to groups such as SMILE. The materials are not for everyone's use. However raw materials in small quantities may be signed out from the Shop by an individual student user, provided that the sign out was cleared with the SMILE group or the group which purchased the materials. Large quantities of raw materials must be cleared with the student's advisor or purchased by the advisor.
28. Keys to the shop may be issued to authorized students through their faculty advisor, who will clear this with the Physics Department Chairman or designed person appointed by the Chair or by the Shop Supervisor.
29. No children, nonstudents, nonstaff, or nonfaculty shall be allowed access to the shop. (See rule 1)
30. All shop users are responsible for reading over these rules and procedures and use is conditional upon agreeing to follow all rules and procedures.

31. Violation of these policies and procedures will result in the revocation of all shop privileges.

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Heat

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Objectives:

The objectives of the **HEAT** Mini-teach is for the students to gain knowledge of heat, participate in hands on activities, and to learn the various vocabulary words associated with heat. This Mini-teach is geared for children in the intermediate grades (3-6) and should be done in a science laboratory in groups of 3 or 4.

This Mini-teach is over a span of two weeks. The vocabulary words should be introduced the first week and one activity should be done each day thereafter.

Vocabulary words:

heat	procedure	measure	kinetic
transfer	materials	bunsen burner	conduction
temperature	results	energy	convection
substance	stretch	observe	radiation
molecules	aluminum	particles	infared rays

Key people to research: Benjamin Thompson, bka Count Rumford
James Prescott Joule

Title: Hot Band

Materials: rubber bands

Procedure: Place the rubber band on your forehead and note the band's temperature; hold the rubber band between your thumbs and index fingers with your thumbs touching, stretch the rubber band, quickly touch the stretched band to your forehead.

Results: The stretched rubber band feels warm.
Why? The rubber band is made of molecules similar to a spring. You pulled the molecules apart and then they sprung back together quickly hitting one another. This is a form of mechanical energy.

Title: Cold Hand

Materials: aluminum foil and a throw rug or thick towel

Procedure: Place a piece of foil on the table and a thick towel next to it. Put one hand on the aluminum and the other on the towel. Observe the different temperatures.

Results: The metal feels colder than the towel.
Why? The aluminum foil allowed the heat to move through it whereas the towel

did not. The things feel cold to the touch when heat energy is drawn away from your skin; things feel warm when heat energy is transferred to your skin.

Title: How Heat Blows Up A Balloon

Materials: balloons, glass bottles, bunsen burner or candle, tongs

Procedure: Stretch the balloon over the neck of an empty bottle. Put the bottle on the net on top of the bunsen burner or set it over a candle using the tongs. Remove the bottle after 3-5 minutes and notice the before and after results.

Results: The balloon blows up while over the heat and deflate when taken away from the heat.
Why? When heat is added, the molecules of air in the bottle move faster and farther apart. The gas (air) occupies more space. As more and more air flows into the balloon from the bottle, the walls of the elastic balloon are pushed out by the air. Heat has caused the air to expand.

Title: Heating Water in a Paper Pan

Materials: paper, paper clips, ruler, pencil, measuring cup for water, bunsen burner or candle, paper towels for cleaning or spillages

Procedure: Measure one inch on all four sides of your paper. Mark them with the pencil. It should form a square. Fold the edges of the paper to form sides of an inch high. Fasten the corners with paper clips. Pour about an half of a inch of water in the paper pan. Place your paper pan of water on the net on top of the bunsen burner or candle.

Results: The water got warm but the paper pan did not burn.
Why? The water is a good conductor and was able to carry away the heat before the paper could ignite.

Title: Explosive (POPCORN)

Materials: unpopped popcorn, hot air popcorn popper, bowl, a cup and paper towels for taking the popped corn back to their desks to eat

Procedure: Observe the shape and size of a few unpopped corn kernels. Place some popcorn into the tray and release it slowly into the popper. (Make sure the hot air popcorn popper is ON.)

Results: The corn kernels change from small, hard, yellow kernels to large, soft, white, ball-shaped structures.
Why? The inside of a corn kernel is filled with starch and water. As the kernel is heated, the liquid water evaporates-changes to gas. The gas expands and pushes so hard that it breaks and the starch is blown outward. That is why you hear the popping noise when popcorn is popping.

Performance Assessment:

Cooperative grouping and evaluation based on their ability to come up with good explanations and filling out an observation sheet. The sheet can be set up similar to the way it is written up leaving the spaces blank. For example:
Title:

Materials:
Procedure:
Results and Why?:

Conclusion:

Heat is energy that is transferred between two things because of a temperature difference. Heat flows on its own from a hotter to a cooler substance, regardless of the amount of each substance. Heat is commonly measured in calories, although the joule is preferred.

Specific heat is a measure of how much heat is required to raise the temperature of a unit of mass of a substance by one degree. Water has a much higher specific heat than almost anything else. The high specific heat of water is responsible for the differences in climates between the East and West Coasts.

Heat isn't a thing. It doesn't occupy space nor does it have weight. Heat is energy that raises the temperature of a thing by causing the molecules in that thing to move faster.

THIS IS HEAT!!!!!!!!

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Measurement

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Objectives:

The main objective of my Mini-teach is to introduce and review the use of the Standard Metric System. After which, students will be introduced to alternative ways to measure distance, time, and temperature. My lesson will be targeted to fourth and fifth graders. My main focus is to allow students to use parts of their bodies to calculate measurements of different objects and areas of space. The activities will be designed to lead the students to an understanding of the measuring system presented. The students will then be able to graph and use their informational data to compare with the other students.

The students will begin with the definition of a Basic Measurement. A Basic Measurement is the distance between two points that can be measured and may be named length, width, height, radius or diameter. In order to use body parts for measuring, the Standard Metric system should be primarily taught. This will help the student and improve his understanding for measuring with alternatives. I am going to work with the simple idea that the distance between two points can be measured.

Strategy:

INTRODUCTION

Two students are asked to open the activity with volunteering to participate in the unannounced subject. They are each given a Superball. In class there are two stairways, where the students are going to engage in a race to the top of the stairs using the Superball. They are to bounce the Superball once on each step as they race to the top. The other students are asked to clap their hands as a measuring tool for time. The recorder announces a winner, which is the student who has made it to the top of the stairs using the least amount of claps. The instructor should not dictate to the students the rhythm or how to clap their hands. The observation point is to watch and listen to the way the students will or will not cooperate with one another concerning the rhythm. Now the students should be asked what they think they just accomplished. The rounded response may be: calculated time by using their body parts, which were their hands.

Students may now be told that their body parts can be used as measuring devices. The remaining activities will allow the students to participate in fun activities that involve measuring length, distance, and temperature, using their own body parts.

Activity: MEASURING THE WHITE BOARDS

Using the span of their hands, the students will create their own hand ruler. Each student will use a undefined length of register tape paper and measure the span of their hand. They will mark the paper after each hand measurement. The length may be any that they desire. This will promote interest on how the students will measure the white boards. If one student measures 10 (ten) hand spans and another measures 5 (five) hand spans, then they should realize that the one with the shorter hand ruler will have to add twice as many times as the other.

When students have completed this activity, they should see the resulting data and notice that all hand measurements are not the same. This will promote questions as to why the hand measurements were different. The instructor can now discuss the advantages and disadvantages of using your body parts as an alternative to the Standard Metric System. Some answers that evolved were:everyone has different hand sizes, some small, some big, you always have your body parts with you as an advantage.

Activity: BODY LENGTH OF THE ROOM

Each student will now use their actual body length to measure as a measuring tool to calculate the length of their classroom. Students will choose a partner and one student will lay on the floor closest to a wall to start measurement. The other student will place his foot at the end of the student's foot who is lying down. The end of the student's foot will be a measurement of one complete body for that student. The group will repeat this until the group has measured the entire length of the room, one way. Students are then advised to try this at home and measure different parts of their home with their body length, with the help of another.

Activity: MEASURE GRASS LENGTH USING YOUR FOOT

Promote discussion on shoe sizes. Explain that they vary, and that women shoe sizes are different from men shoe sizes. Students will go outside. Each child will use their own foot measurement to measure the length of the grass. They will start at the edge of the grass, putting one foot in front of the other and count until the distance is completed. Complete and compare the data with other students.

Activity: MEASURING TEMPERATURE

Students are asked to use body parts to calculate a general estimate of temperature. Materials used includes a cup of hot water, a can of cold pop, and a warm towel. Students will touch each object, telling the other students which objects are warmer and colder without using a thermometer. Students will discuss results and realize that they just used their body parts to measure temperature. Some students may experiment and us different body parts to measure temperature. Some students used their fingers, tongue, and jaw cheeks.

Assessment:

Students should now understand that they can use alternative measuring devices. The fun part of their data is that they can use their very own body parts. They are free and always with you. Disadvantages may include the fact that measuring with body parts can also result in inaccurate measurements because everyone can have different size body parts.

Students will be given a metric ruler. They will be asked to find a part of their body that measures exactly one inch. They can test their findings by measuring a sheet of notebook paper. Now the students will understand that they have a permanent measuring tool right on their body and can be used at all times.

VOCABULARY

body parts
span

MATERIALS

body and body parts
register tape
pencil
Superball
metric ruler

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Probability

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Objective:

Probability: A number that tells how likely it is that something will happen. An educated guess. The purpose of this lesson is to introduce children to the skill of probability. This lesson is designed for grades four and five, however may be used at any grade level depending on the level and the ability of the children.

Materials Needed:

A bag of ten pennies for every two children, color pencils or markers, graph paper, six-sided dice, M & M candy (any variety of M & M candies).

Strategy:

Teacher's Opening:
I have some candy. I am going to place 5 pieces in the bag. Four will be yellow and one will be green. Which will be most likely to pick out of the bag? Which will be least likely to pick? Why do you think? Add more candy to the bag and several different colors until you reach the number 10.

Activity #1: Coin Toss
Each group will receive a bag with ten pennies, a sheet of graph paper and markers. On the graph paper will be the following combinations: HHH,HHT,HTH,HTT,THH,THT,TTH,TTT. The students then will number the left side of the graph paper from 1 to 10 starting at the bottom. Take out three pennies from the bag. Throw the pennies 10 times and see which of the combinations will fall. Shade in the graph according to one of the combinations. Establish with the students the rules. The penny that falls closest to them is 1st, one in the middle is 2nd, one farthest away is 3rd. After the ten tries, have one child from each group come to the front of the class and discuss the outcomes of each throw. Students will then take the entire bag of ten pennies and make one throw. Group together all heads and tape together in a line end to end. Repeat for tails and compare the results.

Activity # 2 M & M
Divide the students into groups of twos. Give each group one bag of M & M. One sheet of graph paper and markers for the colors of the M & M. Have the students to write the colors of the M & M at the bottom of the sheet and number the paper on the left starting at the bottom from 1 to 10. Remove one M & M at a time and color in that color. Let the students do this for the 10 tries. Discuss the outcomes with each group of students. Students may use the remaining M & Ms to complete the graph showing the total number of M & M's in the bag.

Activity #3 Spinner
Give each group a spinner with the numbers 1 through 6. The students are to take three tries at spinning to see if the spinner will stop on the number 1. Students then may illustrate or show the results of the spins on the chalkboard.

Performance Assessment:

Give each group a bag of M & M peanuts, or peanut butter. Graph the number of each color and compare the results with the previous activity results.

References:

World Book Encyclopedia; Aims Activity

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The Effects of Solar Energy

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Anton Dvorak Specialty Academy
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Objectives:

This mini teach is designed for the primary level. Students will learn that solar energy is absorbed and used in all aspects of life. Students will learn that plants will not grow without solar energy, and that planet earth would be so cold and dark that nothing could survive.

Materials Needed:

Activities 1	Activities 2	Activities 3
Solar Print Paper	**Coloring Activities**	**Terrarium**
sunprint paper	work sheet 1	2 liter bottle
solid object	work sheet 2	soil
transparencies	crayons	seeds
card board		water

Strategies:

Activity #1

1 In class place card board box on grass.
2 Place sunprint paper on top of box.
3 Place object on sunprint paper.
4 Place transparencies on top of sunprint paper.
5 Take class outside on a sunny or an overcast day. Do not expose the paper to sunlight until you have assembled the kit.
Finally, when paper is exposed to sunlight an image will emerge.

Activity #2

1. Color picture one (picture of a person exposed to sunlight)
2. Color picture two (picture of flower and trees exposed to sunlight)

Activity #3

1. Cut the 2 liter bottle in half.
2. Place soil in bottom of 2 liter bottle.
3. Place bean or seeds in the middle of two liter bottle then place more soil on top of planted seeds.
4. Pour water into the soil.
5. Finally cover your terrarium with other half of bottle.
6. No more water is needed.
7. Place in sunlight.

Performance Assessment:

Activity #1

Question: By using Sunprint paper students will observe and verbally explain why colors change when exposed to light.

Answer: Solar energy is absorbed by paper, and causes it to change color. Teacher/Student should try this experiment and watch an image emerge.

Activity #2

Using crayons, students will color the pictures that depict the different reaction that relate to solar energy. (Prior Knowledge)

Question: Ask students to bring pictures up and explain why humans change colors?

Answer: Solar energy is absorbed by humans.

Activity #3

This activity allow the students to measure growth and graph the growth of their own plants.

Question: Ask students what made their plants grow?

Answer: Water and solar energy absorbed by plants made them grow.

Conclusion:

These activities cover material included in major textbook series and motivates children to learn, while having FUN. Solar energy is absorbed and used by all things.

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Airplanes

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Objectives:

Designed for Grades 2 & 3. To develop and experiment with flying. To understand basic principals of energy of motion. To make and fly paper airplanes.

Materials Needed:

Materials listed are for groups of four.

paper
pencil
tape
paper clips
pop cans (empty)
string
toy helicopter
balloon

Strategy:

Take two sheets of paper the same size. Crumple one of the papers into a ball. Hold the crumpled paper and the flat paper high above our head. Drop them both at the same time. The force of gravity pulls them both downward. Which paper falls to the ground first? What seems to keep the flat sheet from falling quickly?

Draw a picture of a plane on the board. Write the word lift above the plane. We say the wings give a plane lift and makes a plane go up. Gravity below, drag behind and thrust in front. Ask the students what these words mean. These four forces are always working on paper planes as well as real airplanes.

Take a balloon blow it up and let it go. This will show thrust which makes the balloon zoom across the room. The students will experiment with blowing between the two empty pop cans. We discuss the Bernoulli's Principle.

Each group will make a helicopter and fly it off the 3rd floor. We will go on to make several different styles and designs of paper planes.

Performance Assessment:

Work in groups of four and discuss answers to the questions. Write down results on how planes were made and how long they were able to fly. Did their helicopter fly when launched? Which way did it fly? Students will have the actual paper helicopter and plane as the result of the experiment.

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Thermal Energy Transfer - Conduction

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Objectives:

To examine the thermal energy transfer through a pane glass window and to clarify the physical definitions of heat and thermal transfer.

Background:

Mies van der Rohe, the architect for the IIT campus was known for his extensive use of glass. Many of the campus buildings are oriented in a North-South direction with the major windows facing either East or West. These windows therefore receive either the morning or afternoon sun.

Materials Needed:

Thermometers, transparencies, copper rod, flame source, overhead projector, bubble raft

Demonstrations:

Thermal transfer through a copper rod, bubble raft analogy of a solid

Strategy:

You are going to measure the energy transfer occurring through the windows oriented in each direction. Choose buildings with good air conditioning. The greater the temperature difference, the better the results.

The following date is needed for your computation-
.area of the glass window
.inside temperature
.outside temperature
.glass conductivity K= .84 J/s
.glass thickness-assume l = 10^{-3}

Substitute the above data into the following formula.

$$Q = K \cdot A \cdot \left\{ \frac{\Delta T}{\ell} \right\}$$

Performance Assessment:

Students are required to reproduce this exercise on windows of their own dwelling. The results of their personal investigation solidify their knowledge of energy transfer.

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Radioactive Decay Curve

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Objectives:

Parts of this experiment are suitable for first grade through sixth grade but the intended grade level is seventh through high school.

1. Students will learn to gather and organize data.
2. Students will practice graphing simple data.
3. Students will observe an exponential curve.
4. Students will learn that the points where the quantity becomes one-half as much occurs at regular intervals.

Materials Needed:

Each group of 2 to 4 students will need
30 pairs of dice (60 di)
a container large enough to hold the dice
graph paper

Strategy:

Each group rolls the 60 di all at once. The team removes all di that turn up as either a 5 or a 6. Count the remaining di. Record this information. Gather up the remaining di and roll them again. Continue doing the rolls until there is only 1 di left or 10 rounds have been completed. Students then graph number of roll verses number of dice left.

Performance Assessment:

Subjective: The teacher should observe the students to be sure that the exercise is being done correctly and that data is being gathered and organized.
Objective: The data table and graph can be given a grade.

Conclusions:

Students sometimes have confusion understanding the directions - it is easier to give a short demonstration of what is to be done. Each group usually has an almost perfect result and if all data from all groups is gathered and averaged, a perfect result is guaranteed. The results of remaining di follow this pattern usually very closely - 40 left on the first roll, 27 left on the second roll, 18 left on the third roll, 12 left on the fourth roll, 8 left on the fifth roll, 5 left on the sixth roll, 4 left on the seventh roll, 3 left on the eight roll, 2 left on the ninth roll, 1 left on the tenth roll.
The students love rolling the dice.

References:

Merrill Physics - Teacher Guide

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Cooperation Blocks

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Objectives:

This activity is suitable for K - 12.

1. Students will work together cooperatively.
2. Student teams will assemble 5 geometric square puzzles.

Materials Needed:

Each group of 5 students will need 5 packets pre-prepared with the puzzle pieces.

```
xxxxxxxxxxxxxxxxxxxxxxx   xxxxxxxxxxxxxxxxxxxxxxx   xxxxxxxxxxxxxxxxxxxxxxx
x          x          x   x x                x  x   x         x           x
x          x x        x   x   x             x   x   x  2A   x             x
x          x x   4A   x   x    x    2A     x    x   x     x               x
x          x  x       x   x     x         x     x   x   x                 x
x          x   x      x   x      x       x      x   x x                   x
x          x    x     x   x       x     x       x   x                     x
x  1A      x     x    x   x        x   x        x   x            xxxxxxxxxx
x          x      x   x   x          x          x   x     4A     x        x
x          x  3A   x  x   x   3A     x    4A    x   x            x        x
x          x        x x   x          x          x   x            x  1A    x
x          x         xx   x          x          x   x            x        x
x          x          x   x          x          x   x            x        x
xxxxxxxxxxxxxxxxxxxxxxx   xxxxxxxxxxxxxxxxxxxxxxx   xxxxxxxxxxxxxxxxxxxxxxx


xxxxxxxxxxxxxxxxxxxxxxx   xxxxxxxxxxxxxxxxxxxxxxx
x         x           x   x         x          xx     Cut 5  6" x 6"
x 5A    x             x   x  3A   x           x x     posterboard into
x     x               x   x     x           x   x     these 15 pieces.
x   x                 x   x   x           x     x     Mark each piece as
x x                   x   x x   5A      x       x     indicated.  Place
x         3A          x   x           x         x     the pieces in 5
x                     x   x         x           x     envelopes marked
x                   x x   x        x            x     1A, 2A, 3A, 4A and 5A.
x                 x   x   x       x             x
x               x     x   x      x      1A      x
x             x  5A   x   x    x                x
x           x         x   xx                    x
xxxxxxxxxxxxxxxxxxxxxxx   xxxxxxxxxxxxxxxxxxxxxxx
```

Strategy:

Each student in the group gets an envelope with puzzle pieces. Unfortunately, no single envelope has the right pieces to assemble a square. Students are not allowed to talk or ask for a puzzle piece or in any way indicate that they want or need a piece. However, students may give away any or all of their puzzle pieces to another team member.

Performance Assessment:

Activity is complete when all 5 squares are assembled properly.

Conclusion:

Great fun!

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Circles Minilab

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Objectives:

Parts of this experiment are suitable for third grade through sixth grade, but the intended grade level is seventh through high school.

1. Students will practice measuring in the metric system.
2. Students will learn to gather and organize data.
3. Students will practice graphing simple data.
4. Students will draw the inference that the slope of the line is pi.

Materials Needed:

Each group of 2 to 4 students will need
6 to 10 assorted circular lids (jars, milk containers, coffee cans, etc.)
meter stick
30cm length of string
graph paper
paper to write on to organize the data

Strategy:

Each group measures the diameter and circumference of each lid in their collection. The diameter is measured directly by placing the meter stick across the center; the circumference is measured by wrapping the string around the outside and then measuring the string. The group recorder makes note of the data as each lid is measured. The group then makes a graph of their data ploting diameter on the x-axis and circumference on the y-axis and, hopefully, recognizes that the slope of the line is pi. It is also suggested that a simple calculation of dividing the circumference by the diameter be made by the students for each lid.

Performance Assessment:

Subjective: The teacher should observe the students to be sure that the measurements are being done correctly and that data is being gathered and organized.
Objective: The data table and graph can be given a grade.

Conclusions:

Students from fourth grade through high school should be able to do most, if not all, of the exercise.

References:

Merrill Physics - Teacher Guide

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Probability

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Objectives:

Grade Level: Intermediate elementary (4-6)

a* The student will be able to determine the relationship between equally likely events and their favorable results.

b* The student will be able to graph their results.

c* The student will be able to determine the degree of probability of event.

d* The student will be able to determine if an event is equally likely or not equally likely to happen.

Materials Needed:

Probability board, toothpicks, marbles, toothpick board, cards, dice, cowrie shells, spinners, number cube, coins, peanut butter, jelly, bread, blue and green cubes, unequal and equal spinners.

Strategy:

1. **(c*)** The student will toss 3 coins 60 times to determine the possible combinations of 3 coin families.

2. **(a*)** The student will determine experimental probability of an experiment by removing 2 cubes from a mixed bag of blue and green cubes. The student will then tally the results and compare the experimental probability with the actual probability.

3. **(d*)** The student will determine the likelihood of selecting a peanut butter, jelly or peanut butter and jelly sandwich from a bag.

4. **(d*)** The student will determine the likelihood of selecting any playing card from a hat that is mixed with at least one folded card.

5. **(a*)** The student will determine the number of times a number cube results in 1-2 versus 3-6.

6. **(b*)** The student will toss darts at a dart board, record the results and graph the results.

7. **(b*)** The student will observe a Gauss Curve being formed by marbles being dropped through a probability board.

Performance Assessment:

The student will be able to determine if an outcome is **equally likely** or **not equally likely** from **a**: tossing a coin, **b**: rolling a number cube with faces numbered 1-6, **c**: spinning an unequal spinner, **d**: spinning an equal spinner, **e**: pick a card from cards set up in a pattern: 1,2,1,2, **f**: pick a card from cards set up in a pattern: 1,2,3,3,4,5.

The student will be able to orally explain if the probability of an event happening is 0,1 or between 0 and 1 for the following questions:

1. You toss a nickel and it will land tails up.
2. You will drive a car to school tomorrow.
3. It will snow tomorrow.
4. It will snow sometime during the winter in Chicago.
5. June will follow May.

Students will be able to graph the scores of a test that result in a Gauss or bell curve.

example:														
	scores =	10,	13,	22,	26,	29,	34,	43,	56,	66,	74,	82,	95,	100
	# students	1,	2,	3,	4,	5,	6,	7,	6,	5,	4,	3,	2,	1,

Conclusions:

Exploring the field of probability will help students develop their ability to understand the relationship between equally likely events and the actual results. Understanding this relationship will form the structure for a higher level of logical thinking.

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Metric Olympic Games

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Objective:

The main objective of this mini-teach is for intermediate students to learn estimation and measurement using the metric system, metric lengths, masses, and areas.

Material Needed:

2-3 paper plates or pie pans
3-5 paper or plastic drinking straws
2 bags of marbles
3 meter sticks
cotton puffballs
large sponge
large mixing bowl or bucket
liter measuring set
centimeter graph paper
balance scale with weights
student worksheet

Strategy:

Mini Metric Olympics

1. Work in small groups (5) including a team captain.
2. There are a total of six stations with a different task at each station. Each station should have a task card with complete instructions and materials available. Each group is assigned to one station.
3. Each captain may read the instructions to his team. It is extremely important that, before each activity begins, each student estimates and records his/her estimate on the student score sheet. Captains should check all members on the team before beginning each activity.
4. After each team member performs the activity. He/she measures and records the actual length, mass, volume or area.

EVENT I: COTTON BALL SHOT PUT

1. Have the students predict how far they can throw the shot put and record it.
2. Stand on the starting line and throw the cotton ball. Each student is allowed one throw.
3. Measure and record the shot put.

EVENT II: RIGHT-HANDED MARBLE GRAB

1. Estimate how many grams you can grab with your right hand.
2. Grab a fistful of marbles.
3. Weight them on a scale.
4. Record the weight.

EVENT III: STRAW JAVELIN THROW

1. Predict how many centimeters you can throw the javelin straw.
2. Throw from the starting line.
3. Measure and record.

EVENT IV: PAPER PLATE DISCUS

1. Predict, in centimeters, your throwing distance and record it.
2. Throw from the starting line.
3. Measure and record.

EVENT V: LEFT HANDED SPONGE SQUEEZE

1. Have a sponge soaking in a large bucket of water.
2. Estimate the amount of water, in milliliters, which a student can squeeze out of a sponge.
3. Measure and record.

EVENT VI: BIG FOOT WAS HERE

1. Predict (in square centimeters) the area of your foot.
2. Without a shoe, trace your foot on square centimeter graph paper.
3. Calculate and record the area.
4. Cut out the footprint and put your name and room number on it.

Performance Assessment:

The student score sheets will have 3 columns (the estimated score, the actual score and the difference between these two scores). After the games they should total the third column. The winner is the student with lowest score because the scoring here was designed to measure how close their estimates are to their actual performance.

1. How many liters of water will fill your bathtub? Draw a cartoon and record your data.

2. Select five or more containers of assorted sizes and shapes. Can you arrange them in order from least to greatest and predict their volume accurately? Organize and illustrate your data.

3. Select five or more objects of various sizes and shapes. Can you arrange them from lightest to heaviest and estimate their mass accurately? Organize and illustrate your data.

4. Estimate the distance of a trip to school and back home in metric units. Draw a map to scale that illustrates how far you walk or ride to school. You may choose to do this with a partner and do a combined map so that you are able to make comparisons.

Reference:

Mathematics and Science a Solution, Illustration By Sheryl Mercier,
Book I Introductory Investigation

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View Tube Triangulation

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Objectives:

Measuring Distance; Estimating; Averaging; Standard deviation

Materials Needed:

Meter sticks, rulers, cut down paper towel cardboard tubes

Strategy:

First, get the students to estimate the height of the chalkboard or the doorway. List the estimates and use a calculator to find the average and standard deviation.

Stand far enough away so that you can see the entire object in the tube. Use a proportion to find the height of the object.

$$\frac{\textbf{Height of object}}{\text{Distance to object}} = \frac{\textbf{Distance of tube}}{\text{Length of tube}}$$

List the calculations and again find the average and the standard deviation. Take some time to discuss what they mean again.

Now get a couple of students to measure exactly how big the object is. Have a prize for the best estimate of measurement.

Performance Assessment:

Collect paper with original estimate and calculation of height. Have students write a short paragraph stating how well they think they did on the exercise.

Conclusions:

You can find percentage error in this lab and it has some new meanings to the students. Have them find their % of error. You can also find the probable percentage of error from the standard deviation.

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Models of the Earth and the Moon

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Objectives:

Third grade students will demonstrate the causes of:
A) Day and Night
B) Seasons of the Year
C) Phases of the Moon

Materials Needed:

blue balloons
balloon holder on stick
globe
lamp with transparent lightbulb
markers
styrofoam balls

Strategies:

A) Students form a circle around a lamp with their backs to the light. They make four quarter turns to the left, stopping each time to observe the position of the lightbulb in their field of view (low, high, or absent). Repeat the turns several times with arms extended to the light, saying NIGHT, SUNRISE, DAY, SUNSET. Finally, use a globe, rotate it and note times of day at a fixed location.

B) Children use a marker to draw an "equator" and the letters USA on their blue balloons. They hold them with their sticks slanted on a slight (23 degrees) angle--all pointing to the same corner of the classroom. While standing in a circle around a lamp, they hold a meterstick (or dowel rod) between the lightbulb and the USA to observe the angle of radiation. Since direct rays cause more intense heat and light we can decide which "balloon-Earths" represent USA's summer, autumn, winter, and spring.

C) Children stand in front of a lamp holding a pencil with a styrofoam ball on it at eye level. As they circle their "moonball" they observe and name the lighted parts of it corresponding to the various phases of the moon.

Performance Assessment:

The student will be successful when he can explain to another person--in an oral, written, illustrated or demonstrative manner--what causes day and night, the seasons of the year and the phases of the moon.

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Paper Mache Solar System

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Objectives:

The students will be involved in hands-on laboratory activities to learn:

1) The relative sizes of the planets in the Solar System.
2) The relative spacing of the Solar System.
3) The cause of the phases of our moon.

Materials needed:

Round balloons of different sizes
Plaster of Paris
Strings
Newsprint
9 styrofoam balls
Transparent light bulb
9 dowel rods
Globe

Strategy:

Begin by reviewing what the solar system consists and naming the nine planets in the order of their distance from the sun.

In order to see the relationship of the size of planets and their relative distance from the sun construct models to scale. (See table on the next page.)

Models made of paper-mache can be used. Shape each planet to the desired size and bake it in an oven for one-half hour. For each of the larger planets blow up a balloon to one inch less than the desired size. Mold a half-inch of paper-mache over the balloon and let it dry for several days.

The planets can be suspended by strings from the ceiling of the room. Arrange them in the order from the sun.

For the relative distances of the planets go out on the sidewalk. Designate each student to represent each planet. Reduce each distance to human footsteps and measure steps down the sidewalk.

To show the phases of the moon, set a lamp without a shade on a table in a dark room. Stand several feet away from the lamp. Hold a ball out in front of you so it is in line with your eyes and the bulb of the lamp. The light is the sun, the bulb is the moon, and you are on the earth. Now move the moon (bulb) slightly to the left of the bulb. How much of the moon is lighted at this point. Turn on your heels so that the ball moves in a circle. At which point is there a full moon? a new moon? a quarter moon?

Conclusions:

The students could make a drawing of what they created. They could write a composition showing step by step how to construct the models.

For the phases of the moon, the students could work with the real moon. Every three nights for one month they can diagram the shape of the moon that is reflecting light. Have them date their pictures. If a night is overcast, leave a space in their series of drawings. They can fill in the empty spaces at the end of the month to show the phases of the moon that did occur on those cloudy nights. Does the moon rotate as well as revolve? (Yes)

Planet	Average distance from sun (km)	Scale distance from sun (cm)
Mercury	58 000 000	5.8 (5 footsteps)
Venus	108 000 000	10.8 (10 footsteps)
Earth	150 000 000	15.0 (15 footsteps)
Mars	229 000 000	22.9 (22 footsteps)
Jupiter	777 000 000	11.1 (11 footsteps)
Saturn	1 426 000 000	142.6 (142 footsteps)
Uranus	2 876 000 000	287.6 (287 footsteps)
Neptune	4 490 000 000	449.0 (449 footsteps)
Pluto	5 914 000 000	591.4 (591 footsteps)

Scale of distances 1 cm = 10 000 000 km

Planet	Scale diameters of planets
Mercury	.76 inches
Venus	1.90 inches
Earth	2.00 inches
Mars	1.06 inches
Jupiter	22.36 inches
Saturn	18.00 inches
Uranus	7.74 inches
Neptune	7.8 inches
Pluto	.54 inches

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Earthquake Waves And Their Destructions

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Objectives:

1. Students will learn characteristics of primary waves and secondary waves.
2. Students will learn how to measure the magnitude of waves.
3. Students will learn how to find the epicenter of earthquakes.
4. Students will learn why waves are more destructive in some areas than others.

Materials:
Activities are recommended for groups of four.
ropes, slinky toys, graphing paper, pencils/markers, ring stands with cross bars carts with wheels, large floor-size erasable world map, 2 liter clear plastic bottles, sand, tin foil pans, plastic and wood model houses, containers of water, stop watch, and spring scales.

Strategy:

Introduction: Today, we are going to investigate the two types of earthquake waves. They are surface waves and body waves.

Vocabulary Building through discovery: Looking at the word "surface". Through the use of questions, the students should be able to infer its meaning by directing the students to the three parts of the earth [crust, mantel, and core]. "Surface" should be similar to the crust of the earth. "Body" should be similar to the earth's mantel and core.
Ex: What part of the earth would be the surface?
What part of you is the body?
What parts of earth would represent the body?

First, we will be discovering the two kinds of body waves.

Activity: Those "Jumping Waves"

1. Give each group a **jump rope** and let them create waves.
2. Allow one student from each group to draw the kinds of waves created.
3. Use the drawings to identify the kind of waves that ropes create as being "transverse waves".
4. Label the various parts of a transverse wave. The "crest" can be the high density. The "trough" can be your low density. "Wavelength" must have one crest, and one trough.

Activity: Those "Slinky Waves"

1. Give each group a **slinky**, and allow them to create more waves.
2. Allow one student from each group to draw the kinds of waves created.
3. Label all the waves that are "transverse waves", and identify the new waves as a "compressional wave".
4. Label the parts of the "compressional wave". The part of the slinky that

is tight or close together is called "compressed". The loose part of the slinky is known as the "rarefaction".

Activity: The "Race"

1. Take the longest **slinky**, and a **spring scale**. At various tension, let the students use a **timer** to see which waves travel the fastest. Take at least three timings. "Compressional Waves" should win this race. Therefore, we are going to call them "Primary Waves" or "P Waves" for short. Now, "transverse waves" came in second place, we will call them "Secondary Waves" or "S Waves".
2. "Surface Waves" always occur at the surface or the "crest" of the earth. This wave rides on top of the " P Waves" and the" S Waves", so it is called the "Love Waves" or "L Waves". " Surface Waves" are the most destructive wave.
   "Compressional Waves" displace soil, sand, and rocks in front and back along its path. "Transverse Waves" displace material perpendicular along its path.

   The first signal of an earthquake is a sharp thump, compressional waves, shear waves and finally the ground rolls caused by surface waves.

Activity: Measuring Waves with a seismograph

1. Take a **ring stand** attach a **string** long enough to reach the surface of the **cart.**
2. Tie the other end of the string to a **marker**, so that, the tip of the marker touches the graphing paper.
3. Make a chart on the graph paper. Let the y-axis represent magnitude, and the x-axis distance.
4. Next, shake the table to create an earthquake using low intensity to high intensity.

   There are two ways that scientist measure earthquake waves. They use magnitude, or intensity. The seismograph measures "magnitude" which deals with the waves along. "Intensity" measures destruction of earthquake waves by the number of deaths, and other visual means.

   When I refer to "low" or "high" intensity, it will relate to force or energy applied.

Activity: Locating, and Plotting Epicenters

1. Place a large erasable **world map** on the floor.
2. Using prepared card containing latitudes, and another set with longitudes coordinates of various earthquake locations. Give each student a card.
3. Call out coordinates in pairs.
4. Next, give each child a **toy car**. They are to place their cars on the appropriate latitude or longitude lines.
5. Roll the cars on their appropriate line and mark the point of intersection.

   Before this activity, you may take the students through directions finding hemispheres, locating continents and oceans.

Epicenters are the origin of earthquakes.

Activity: Is the Earth a Solid Core? Liquefaction

1. Take a **tin pan** and pour **sand** into it. Just enough to cover the bottom.
2. Pour just enough **water** to saturate.
3. Pour another layer of sand.
4. Place a wooden house, or a monopoly game house on top of the sand.
5. Create an earthquake, either shake or strike the desk.

What happened to the house?

Activity: Liquefaction in a Bottle

1. Pour **sand** into a **plastic or jar bottle** using a **funnel**. The sand should measure about 2-3 inches in height.
2. Use a large nail and put a hole into the lids.
3. Put water into another **plastic bottle**.
4. Take the lids and run **plastic tubing**. Make sure the tubing is long enough to reach the sand in the other bottle.
5. Drop your model house into the bottle of sand.
6. Put the lids on both bottles.
7. Squeeze the bottle containing the water, and saturate the bottle containing the sand.
8. Create an earthquake.

What do you observe?

Liquefaction occurs because of unconsolidated sand, clay or rocks. Location is important in deciding on where you should live in this world.

9. Review the activity on epicenters. Bring out the floor map.

Where do we find most of our epicenters located?
Are they located by water?
What type of soil do you find?
Is water important to creating liquefaction?
Where would you choose to live?

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Plate Tectonics

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Objectives:

After this experience the students should
1. be able to identify the three main parts of the earth
2. be aware that the earth's crust is made up of pieces called plates
3. be able to state the theory of Plate Tectonics
4. be aware that convection currents could cause the earth's crustal plates to move
5. be able to identify plate divergence as a possible explanation of Continental Drift, seafloor spreading, and volcanic activity near the Mid Atlantic Ridge
6. be able to identify plate convergence as a possible explanation of earthquakes, volcanoes, mountain building, subduction and the rock cycle.

Materials needed:

1. One chart showing the three main parts of the earth
2. A boiled egg and a plastic knife for each group of five students
3. A puzzle showing the large plates of the earth (one per student)
4. A hot plate, aluminum cake pan, water,and balsa wood pieces. (one set)
5. A 750 ml beaker, a pill bottle, two-hole rubber stopper to fit the pill bottle, glass rods, hot water, cold water, two pennies, and food color (one set per group of five students)
6. A sheet of butcher paper 2 m long, 2 demonstration tables, a silhouette of Africa and South America, a marking pen (one set up per class)
7. 2 damp wash cloths per group, 4 popsicle sticks per student, a lump of clay for each student
8. A shoe box, small garbage bag, scissors, newspaper, two boards (30cm X 30cm X 5cm), five pounds of sand, water to dampen the sand

Strategy:

Activity I
Show students the core, mantle, and crust of the earth using a chart. Pass a boiled egg and a plastic knife to each group of two. Have one of the students cut the egg in half. Each person gets half of the egg and will use it as a model to discover the three main parts of the earth. Tell the students that the cracked shells represent the part of the crust called plates.

Activity II
Pass a jigsaw puzzle to each student and instruct them to put it together. Students should discover that the puzzle represents the earth's crustal plates. They should identify the continents and oceans. They should observe that some plates are composed of all continent, all ocean, and a combination of both. Introduce terms by having students move two adjacent plates apart (Divergence); move two plates together (Convergence); and move two plates so that one moves up and the other down with the pieces rubbing past each other (Transformation).

Activity III

Tell the students the theory of Plate Tectonics.
The earth's crust is composed of seven or eight major plates and several smaller ones. These plates move.

Activity IV
Let students relate science equipment to the earth's model. Hot plate - core, water (in an aluminum pan) - mantle, balsa wood chips - crustal plates. Heat the water to boiling. Put chips in the center of the pan. Students should identify the boiling water as a convection current that causes the balsa wood chips (crustal plates) to move.

Activity V
Each group of four students will get a 750 ml beaker filled with cold water. They will fill a pill bottle with hot water, 3 drops of food color and two pennies to keep it from floating. They will cut 2 pieces of glass tubing 8 cm long (straws can be substituted for the glass tubing). Insert a tube into each hole of a two hole rubber stopper and position the tubes so that one sticks out of the stopper more than the other. Insert the rubber stopper into the pill bottle. Wipe any colored water off of the bottle. Hold it by the rim and lower the pill bottle into the center of the beaker of cold water until it sits on the bottom of the beaker. Keep the pill bottle upright. Students should discover that this is a convection current and the colored water looks like lava coming from a volcano.

Activity VI
Students will observe a model of diverging plates. The teacher will push two display tables together leaving a small space between them. She will tell the students that the tables represent two Atlantic Ocean plates and the opening represents the Mid-Atlantic Ridge. The teacher will cut off butcher paper two meters long and slide it through the opening (Mid-Atlantic Ridge) so that 5cm of paper is showing on the surface of each table on each side of the ridge. Have two students each label their paper lava/new crust and mark it with a ruler and pen. Have the student helpers pull out 5cm more of butcher paper and mark it lava/new crust. Have them also tape a silhouette of South America on the left crust and Africa on the right crust. Have helpers pull out 5cm more of butcher paper and mark it as before. Continue the previous steps until the students are able to discover that the seafloor is spreading because new crust is being added. The Atlantic Ocean is getting larger. The continents are moving apart. Volcanoes are forming volcanic mountains and islands along the Mid-Atlantic Ridge. The Atlantic crustal plates are moving apart. (Divergence)

Activity VII
Students should discover that while the Atlantic plates are diverging, the Pacific plates are converging. Ten students will be Pacific crust. They will hold hands to form a circle to define the size of the earth. Drop hands. Ten more students will represent the new Atlantic crust. They will join the earth's circle two at a time at the same place. They will diverge and push the Pacific plates closer together (converge). As more and more new Atlantic crust join the line, some of the Pacific plates will move in front of the other Pacific crustal plates to make room. (This represents subduction). Students should discover that as the new Atlantic crust diverged the Pacific crust converged. They should discover that the Pacific crust made room for the new crust by moving out of the way through subduction.

Activity VIII
Teacher will explain terms subduction, Asthenosphere, and rock cycle.

Activity IX
Students should be told that continental crust does not subduct into the Asthenosphere. Students will use two damp wash cloths to represent continental crust. They will diverge them and discover that volcanoes could develop between the plates. They will converge (push together) the continental crust. They should discover that the rolls and the folds look like mountains. Use popsicle sticks to form anticlines and synclines. Students should discover that pressure which forms mountains and valleys also causes breaks called faults and sudden movements called earthquakes. Use clay to form various mountain forms.

Activity X
Use a Fault Box to observe a model of an earthquake. Cut the bottom of a shoe box with scissors. Cut a small garbage bag so that it will hang down through the bottom of the shoe box by about l0 cm. Attach the bag to the side of the shoe box. Cover the area with newspaper. Place two boards (30cm X 30cm X 5cm) on the newspaper side by side. Place the shoe box on the crack between the board so that half of the box is on each side. Pull up the garbage bag so that it forms the bottom of the shoe box. Fill the box with wet sand. Pack it down and smooth it out. Have a helper hold the box steady. Have students come up in groups of four or five. Let them observe what happens when one of the boards slides out from under the fault box. Return the board and smooth the sand. Slide both boards apart until they are separated 15cm. Do not pull boards all the way out. Return the boards and smooth the sand. Slide both boards apart and push back together. Return the boards and smooth the sand. Slide both boards alternately up and down, back and forth so that the sides rub against each other. Observe results after each trial.

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The Science of Airplane Flight

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Objective:

After this experience the student should:
1. Be able to define lift, drag, ailerons, rudder.
2. Be able to make a sketch showing the forces which act on an airplane in flight.
3. Be able to explain Bernoulli's principle.
4. Be able to explain how angle of attack is used to increase lift.
5. Be able to identify the control surfaces of an airplane.
6. Be able to explain the movement of air around an airfoil.

Materials Needed:

Patterns, styrofoam meat trays, scissors, razor blades, sand paper, glue, clay, paper clips, tooth picks.

Strategy:

Throw a ball into the air a few times then ask:
l. Why does the ball come down?
2. Why is an airplane able to stay in the air?
3 What are the forces acting on an airplane that allows it to stay in the air?

Have students fan themselves with paper, and identify the forces that acted upon the paper. (thrust, drag).

Have the students hold a piece of notebook paper on the bottom corners. Placing the paper to their mouths and blow upon it. Then ask:
l. What happens to the paper?
2. Explain your answer.

Have students cut out and put together a puzzle of a plane and compare it with the labeled model on overhead projector.

Have students make gliders and test fly them. Then ask:
1. Why did the gliders fly?
2. Why did some of the gliders not fly?

Convection box demonstration, use two small juice cans with the ends cut out, a candle, and a cardboard or wooden box. Use to show up and down drafts.

Pop cans demonstration: have students blow between two pop cans an ask:
1. What happened when you blew between the two pop cans?

Have students build styrofoam airplanes and test fly them and discuss the results.

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Aerodynamics

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Objectives:

Demonstrate skill in hypothesis formulation, identification and control of variables, data collection, organization and interpretation of data.

Discover and understand the basic principles of aerodynamics, including the roles and identity of natural forces involved.

Discover how the force of **GRAVITY** is overcome by the curved shape of an airplane wing and air pressure.

Discover why air pressure is lower moving across a curved surface vs. a straight surface, creating **LIFT**. (Bernoulli's Principle).

Discover why an airplane will stall if there is too much air pressure under the wing.

Discover how **THRUST** force is used to overcome **DRAG** force, caused by friction.

Materials needed:

paper - ditto, 2 sheets per person
- 2cm. x 8cm., 1 per person
- newsprint for graph, 1 per team
- cups, 2 per person
- clips, 5 per team

launcher, wood, with rubber band and thumb tack
floodlight

markers or crayons
small box fan
cool air vaporizer
scissors
cellophane tape

Strategy:

Without any verbal explanation, the teacher will fly a paper airplane four times, measureing and recording the data on chalkboard after each flight. (The **first** flight will have 0 paper clips; the **second**, 1 paper clip; the **third**, 3 paper clips; and the **fourth**, 5 paper clips.) The teacher will make a graph showing the distance of each flight then ask three questions, "What did you see?" "What was happening?" "What does the chart show?" The students will be able to read the graph; identify the source of the data; and then label it to show "Average horizontal distance".

The students will be encouraged to hypothesize the reason some airplanes flew straight, others either went to the right or to the left. (Added weight, and uneven folds of the airplane.)

The students will be grouped into teams of not more than four.

Activity 1: The students will make identical airplanes from one sheet of ditto paper. **Step 1**, fold paper in half, the long side. **Step 2**, turn paper over, like an open book (spine up). **Step 3**, fold upper corners toward center fold. **Step 4**, fold down set of corners toward bottom of paper. **Step 5**, repeat Step 3. **Step 6**, fold back along original fold. Place folded portion on bottom. **Step 7**, bring one wing portion down to fold, starting at the nose carefully fold down to make a wing, repeat for second wing. (It is important that the creases are even and sharp.) The students will be given an opportunity to test their planes for air worthiness. Following this test flight, they will then make another airplane. Each team member will test their planes to determine the MOST air worthy plane to be used in the next activity.

Activity 2: Teams will repeat the teacher's demonstration, using only ONE plane. However, they will fly three trials of each, and record the distance on a data sheet. Using the data, a graph of the "Average distance of each flight," will be made. The students will explain their graphs and compare them to the other graphs. (The added weight affects the distance because of **GRAVITY**, and the placement of the clips on the keel of the plane, = center of gravity)

Activity 3: Each student will hold the end of a 2cm x 8cm piece of paper to their mouth and blow over the top of the paper. (The end of paper rises.) Now blow underneath, what happens? Measure 3cm from the short end of the paper and fold, tape the ends. Drape the untaped end between the forefingers of each hand, now blow over the top. What happens? Blow hard across the flat side. What happens?

Activity 4: Pass out 2 paper cups to each student and a pair of scissors per team. Students should hold the cups about 5cm (2") from their mouth and blow between the rims of the two cups. (The inner cup will pop out.) Cut out the bottom of one of the cups, place it on the bottom of the other cup, and blow again. The cup will no longer pop out. (Air pressure is lost through the bottom of the cup.)

Activity 5: Using a box fan, blow vapor from vaporizer over a wing model to show how air travels over the curved and straight surfaces of an airplane wing. Students will discuss what they saw. Repeat the demonstration. Raise the front edge of the wing and repeat the vapor (air) flow demonstration. Discuss and repeat. For the third demonstration, raise the front edge so that the vapor hits the bottom of the wing. Ask students what would happen if this was an airplane? (Plane would stall and fall). Using an overhead projector transparency with the three wing positions, ask a student to show the path of air using arrows. Is this similar or different from the paper cup?

Activity 6: Introduce Bernoulli's Principle. It takes more energy to move over a curved surface, less pressure causes **LIFT FORCE**. Gas, steam, water, and other liquids are similar to air.

Activity 7: Using a model glider placed on a table or desk, ask students to hypothesize why the plane isn't moving. Push it, why isn't it lifting. What is holding it down? (**GRAVITY**) Ask students to explain how Bernoulli's discovery applied to counteract the **FORCE OF GRAVITY**. Have a student hold a sheet of paper in his outstretched hand, then have him run with it. The paper will **LIFT**. Ask the students to explain how this is applied to the glider.

Activity 8: If the glider is pushed it will move and then stop. Ask students to explain how friction causes the glider to stop. This is called **DRAG FORCE**. How does an airplane overcome **DRAG**? What causes an airplane to move? A propeller or jet engine creates **THRUST FORCE**. When a plane speeds up, **THRUST** is greater than **DRAG**. **THRUST** is the force that pushes an airplane forward through the air.

Aerodynamics is the study of air as it moves around objects. Discuss other areas where Bernoulli Principle is applied. (Automobiles, boats, trains have smooth surfaces, reducing friction, this is called "streamlining"). Engineers designing skyscrapers, suspension bridges, automobile carburetors, pumps, and water driven turbines, all use aerodynamics.

Performance Assessment:

Make a diagram of air currents, using arrows to show the direction of the air above and below an airplane wing. Indicate the **FORCES** involved, and where more air pressure, and less air pressure is present.

Make a diagram of an airplane. Show the direction of the four main **FORCES** that affect flight. Pair the forces. Describe the balance of forces.

Rubric:

5 points - Identification of less air pressure over the curved surface of the wing, and more air pressure under the wing. The direction of the forces of GRAVITY, LIFT, THRUST, AND DRAG, are correctly drawn. GRAVITY vs. LIFT, and THRUST vs. DRAG are paired. A correct description of how LIFT and THRUST balance GRAVITY and DRAG as opposing forces.

4 points - Indicates an understanding, but has not described how the forces are balanced, **or** has not identified the air pressure.

3 points - Has not indicated the correct direction of the forces of GRAVITY, LIFT, THRUST, and DRAG, but has described how the forces are balanced.

2 points - Has not identified the air pressure.

1 points - Has not written anything, has only drawn arrows.

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The Puzzle

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Objective(s):

The main objective of the Mini-teach is to make students aware of some of the ways they process information so that they may become more skilled. To develop Thinking Skills in science students.

Materials needed:

A puzzle (preferable manipulative, not crosswords, etc.) of sufficient difficulty to challenge even the best students at the teaching level. This miniteach used a spectral color matching puzzle with many, many incorrect trials but apparently only one correct solution. There should be one puzzle per student.

Strategy:

1. The puzzle is introduced to the class by giving each student a puzzle. The students are told to look at the puzzle carefully and record any and all particulars of the puzzle. Time allotted for the part of the exercise will vary with grade level and complexity of the puzzle.

2. As students begin completing step 1, start a discussion about the puzzle. Typically this will include size, color, shape, number of parts, patterns, similarity (or differences) of parts, etc. Before the discussion ends it is important that each student knows the point of the puzzle. **Note - they have not yet been asked to solve the puzzle**.

3. After the discussion of the puzzle the students are given the following assignment. The student is to formulate a clear method of solving the puzzle. The solution is to be written in such a way as to be used by anyone at this grade level to quickly solve the puzzle. **Note - they have not yet been asked to solve the puzzle**.

4.After allowing sufficient time to formulate a solution bring the students into cooperative groups and allow them to formulate one grand unified solution to the puzzle. The grand unified solution is carefully put in writing and given to the teacher.

Performance Assessment:

The teacher takes each of the grand unified solutions and distributes them to each cooperative group, being careful not to give a group their own solution. Each group is now told to **solve the puzzle** using the grand unified solution they have been given. Time needed to solve the puzzle is to be recorded.

A scoring rubric may be developed based on any number of criteria, such as clarity of instructions, shortest time for a solution, brevity, reduction of incorrect trials etc. The winner gets a big hand. See the Sample.

Scoring Rubric (Sample)

5 Points- The solution was clear, concise and allowed anyone to solve the puzzle in less than 3 minutes. It included the mathematical possibilities of the number of incorrect trials as well as the number of possible correct solutions. It also noted the puzzle color very nearly matched the visible spectrum as learned in physics. Finally it provided a painless solution for eliminating the national debt.

4 Points- The solution was clear and allowed the puzzle to be solved in less than 10 minutes with a minimum of wrong moves.

3 Points- The solution worked, but was long and/or difficult to understand. Time was wasted modifying the solution.

2 Points- Some order and logic existed in the solution. It was unclear and allowed you to make the same errors repeatedly.

1 Point- Solution was Trial & Error.

0 Points- Solution confused, frustrated and discouraged one from trying the puzzle.

Conclusions:

An exercise such as the puzzle, attempted at the high school level should include the following thinking skills:

1. Attributing
2. Analyzing
3. Predicting
4. Comparing/Contrasting
5. Inferring
6. Problem Solving
7. (Cause & Effect depending on the puzzle)

In the discussion follow each step in the strategy the appropriate thinking skill(s) should be mentioned by name and discussed. Example after step 1 Attributing (observations) and comparing and contrasting would probably be appropriate. Eventually the students should begin to be aware of how they think and become more skillful thinkers and learn some physics.

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Kinds of Weather And What to Wear

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Objectives:

After each demonstration, the student should be able to

1. recognize cloud, and fog formation;
2. recognize the characteristics of rain, snow and wind;
3. determine dress attire for each kind of weather;
4. make a weather book.

Materials needed:

portable burner
pan of water
ice cubes to cover the tray
plastic tray
an electric fan
raincoat
umbrella
galoshes
hat
paper fasteners
crayons
a jar
warm water
matches
a sheet of black paper
cut white paper
snowsuit
snow boots
mittens
manuscript paper
construction paper

Suggested Strategy:

Take the jar and tape black paper on the back of the jar. You can't see through the jar. Fill one third of the jar with warm water. Have the bag of ice and matches nearby. Light the match and hold it over the jar opening. After a few seconds, drop the match in the jar and cover the top of the jar with the bag of ice. Observe the inside of the jar against the black paper background.

While bringing the pan of water to a boil, cover at least half of the plastic tray with ice. Hold the tray of ice above the pan so rising steam hits the tray of ice. What happens to the tray? Continue holding the tray until large droplets form and fall. It's rain.

Turn on an electric fan and proceed to pour cut white paper in front of the fan. This shows some characteristics of snow. Incidentally, a German meteorologist, a scientist who studies the atmosphere and weather, discovered cold clouds. The discovery found that when water and ice coexist, the water is attracted to the ice. At certain temperatures, snow is formed.

With cut paper streamers taped to the front of an electric fan, turn the fan on. Wind is characterized.

With an appropriate wardrobe of clothing, students will model the proper attire for a given kind of weather.

Performance Assessment:

Given a weather phrase, student will brainstorm short stories. After brain-storming, the student will expand phrase into a complex sentence. The student will write an ending sentence to a short story.

In the space provided at the top of the manuscript paper, the student must draw story illustrations. The main idea must be emphasized with a variety of details. All pictures must be colored.

Given construction paper, the student will make a cover page depicting an illustration of a favorite weather story, the title of a weather book, and proper identification.

All stories are organized and fastened onto cover page for completion of a weather book.

The Assessment Scoring Rubric

5 Points

The weather book completed with at least five stories with the appropriate illustrations, colorful cover page and the proper identifying information written at the bottom of the page.
Given phrases should be expanded in complex sentences. All other sentences should be details or related to the main idea. The final ending sentence should tell how the subject feels. All illustrations must be colored.

4 Points

The weather book is completed with a minimum of four stories with the appropriate illustrations, colorful cover page and the proper identifying information.

3 Points

The weather book consists of two completed stories, illustrations, cover page and illustrations.

2 Points

The weather book consists of colorful cover page, incomplete stories and identification.

1 Point

Trial and error.

0 Points

No participation.

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Heat Absorption

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Objectives:

Grades 8-9

1. Describe how the average kinetic energy of matter is measured.
2. Distinguish between heat and temperature, and calculate a change in a substance from one state to another.
3. Understand the value of precise data for use in a comparative study.
4. Demonstrate that a colored surface will absorb more heat from a source of light than a white surface.
5. Explain how instruments detect and measure changes in heat and temperature.
6. Identify the ways in which heat is transferred.
7. To investigate the absorption of heat energy by matter.
8. Analyze data and establish a relationship between factors involved.

Materials Needed:

Thermometers, tin cans, black and white construction paper and cloth, meterstick, styrofoam cups, charcoal, sand, water, candles, lamp, ice cubes, graph paper, radiometer.

Recommended Strategy:

Station 1 Discovery Centers - Directions:

A. Place the clip lamp directly above the cups at height 30cm.
B. Design your own table for recording data. Enter the temperature shown on the thermometer for each material.
C. Turn on the lamp. Record the temperature of the material in each cup after 1, 2, and 5 minutes and report:
   1. Construct a graph of the heating data. Represent each material by a different type of line.
   2. Which dry material showed the greatest increase in temperature.
   3. Which wet solid showed the greatest increase in temperature.
   4. Did the wet charcoal or the dry charcoal show a greater increase in temperature.
   5. Did the wet sand or the dry sand show a greater increase in temperature.
   6. How did the increase in the temperature of the water compare to the increases in the temperature of the solids?
   7. When the light was turned off, which material showed the greatest decrease in temperature.

Station 2 Miniature Greenhouse Discovery Center - Purpose: To investigate the conversion of light to heat energy - Directions:

A. Arrange a clip lamp so bulb is 50cm from plastic wrap.
B. Design your own table for recording data, enter temperature shown on each thermometer then turn on the lamp. Record the temperature inside and outside of the box every 30 seconds for 5 minutes and report:
   1. What is the dependent variable in your data? What is the independent variable?
   2. Construct a line graph of the heating data collected in directions above. Show temperature on the vertical axis and time on the horizontal axis. Use

a solid line for temperature inside, dotted line for temperature outside.
3. Construct a line graph of the cooling data collected in step B. Follow the procedure in number 2 above.
4. How did the temperature change inside the box compare with those outside?

Station 3 Color and Heat - Directions and Experiment:
1. After lighting the candle, allow a drop of wax to drop on to each sheet of black and white paper.
2. Place the lighted electric bulb exactly between the two sheets of paper about 3 inches from each. OBSERVATIONS? CONCLUSIONS?

Station 4 Color and Heat Absorption - Experiment:
1. Hold a tin can in a candle flame until it is completely coated with soot.
2. Pour water into both cans until they are full.
3. Record the temperature of the water in each can.
4. Put the two cans of water directly in the sunlight or near a lamp.
5. Take the temperature of the water in each can every five minutes for about a half-hour. OBSERVATIONS? CONCLUSIONS?

Station 5 A Material's Effect on Radiation - Directions:
1. Place the Black and White pouches flat on a table. Place a thermometer into each pouch. Place the light source 10cm above the pouches.
2. Turn the light on and record the temperature of each pouch each minute for 6 minutes.
3. Repeat using the black paper. OBSERVATIONS? CONCLUSIONS?

Discussion and Follow-up:
- At Specific intervals during the demonstration, students should be given turns for taking temperature readings and recording them on a chart.
- Predict what they think the outcome of the demonstration will be.
- After about 6 readings, or whenever a difference in the temperature of 3 substances has been noted, the data collected should be analyzed and a determination made as to the comparative rate of heating of soil and water.
- Students should be encouraged to report personal experiences at the seashore, swimming area, wearing light colors in summer, dark colors in winter and relate the demonstrations to an actual situation.

Summary Statements:
1. The temperature of matter changes when the amount of heat in it changes.
2. Heat energy travels from a warmer to a cooler location.
3. A thermometer is used to measure the temperature of a substance.
4. Black absorbs all colors of light, so more energy is taken in per unit of time; white reflects all of the colors of light.
5. Much of radiant energy of the sun is changed into heat when it strikes objects. The black or dark colored materials and objects give off and take in heat the fastest. The radiant energy absorbed changes into heat.
6. The lighter, white and shiny objects tend to reflect more of the sun's energy.
7. Water, with its high specific heat, will tend to slow any temperature changes when added to the solids.
8. When exposed to the same source of heat, soil heats at a faster rate than water.

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Radioactive Decay/Half-Life

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Objective:

(for grades 3-12)

To demonstrate a model whereby students will perform a hands on application of determining the half-life of a radioactive element.

Materials Needed:

The following materials are needed for each group of 2-4 students.

1) corn candy
2) shoe boxes
3) marker
4) paper
5) pencil
6) graph paper

Instructors Preparation:

1) Have available shoe boxes for each group of 2-4 students.
2) Using the marker place an X at one end of the shoe box.
3) Place 100 pieces of corn candy in each box.
4) Diagram a model data table showing # of corn candy and # of years.

Procedures:

1) Make a data table as shown and make some predictions.
2) Remove the lid and empty corn candy into box.
3) Close the lid and shake the box gently 5 times.
4) Remove the lid and remove all corn candy with the point facing the (X) inside of the box.
5) Count & record in the data table the number of corn candy left after each opening.
6) Repeat steps 3-5 until all of the corn candy is gone.
7) Graph the data from the data table onto graph paper, showing # of candy corn on the vertical & # of years on the horizontal.

Expected Results:

Students should discover that after each shake (which represents years) & the removal of the corn candy (which represents atoms), there is a definite pattern of decay.

Students discover that it was impossible to predict when or how many corn candies would decay.

Evaluation:

The students' data table and graph curve will determine whether the students performed the experiment.

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Weather Facts

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Objectives:

(grades 3-9)

1) To understand why certain phenomena occur in the atmosphere
2) To learn how weather elements are measured
3) To learn to make and/or use weather instruments
4) To become familiar with weather terminology
5) To distinguish between myths, superstitions, and scientific predictions

Materials needed:

(for groups of six-eight students)
large room thermometer, a weather vane, card-board, narrow jar or test tube, balloons, red narrow balloon, red and blue food coloring, two large jars, aluminum pan, ice cubes, plastic transparent container (shoe box, sweater box, etc.), hot and cold water, candle, plastic wrap, piece of wool, torn scraps of paper, comb, paper bags, tornado in a bottle, sponge, index cards

optional: patterns and materials to make weather vanes and/or pin-wheels

Strategy:

teacher preparation:

1. Make simple weather vane
2. Prepare activity sheets
3. Make tornado in a bottle
4. Make pattern worksheets for weather vane and pinwheel
5. Check books for myths, superstitions, and weather facts
6. Boil a quart of water
7. Have two trays of ice cubes available
8. Set up weather stations

Class activities:

1. Read and discuss myths, superstitions, truisms associated with weather
2. Present vocabulary: air mass, front, high, low, humidity, wind, precipitation, pressure, temperature, tornado
3. Do demonstration with clear container, jar of hot water colored red, jar of cold water colored blue (add salt to the water), divider. With divider separating container in half, pour hot water in one side and cold water in the other side simultaneously. Remove divider and observe
4. Students should report to a weather station

Weather stations

1. Wind-objective: to discover that wind is moving air. Use sponge to wet board. Fan with cardboard. Write north, south, east, west on index cards. Have child hold weather vane with index cards around him. Students will blow and child with weather vane will point it in the direction from which the wind is blowing.
2. Temperature-Thermometer: to learn to read a thermometer. To discover that temperature changes cause fog and clouds. Use room thermometer. Place ice cubes in aluminum pan and hold over jar of hot water. Place long red balloon in test tube. Blow balloon up slightly.
3. Thunderstorms/Static Electricity/Tornadoes: to understand weather phenomena. Blow up paper bags. Break two of them vigorously. (thunder) Rub comb with wool. Hold over bits of paper. Rub plastic, hold in palm of hand, turn hand over. Experiment making tornadoes using the tornado in a bottle. (15-20 ball-bearings, 1 liter plastic bottle, 2-3 drops of detergent)

Conclusions:

After completing activities, students should:
1. Understand why certain phenomena occur in the atmosphere
2. Know that weather elements are measured by instruments
3. Be familiar with weather terminology

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Using the Senses as a Means of Observation

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Objective:

The purpose of this activity is to have students use their senses in various situations. The situations are such that students find out that their senses are not always accurate.

Material needed:

(For each group of four)
Orange juice, nondiet cola, apples, candy (such as mint or lemon drops), plastic dishpans or washbasins, (large battery jar instead of plastic dishpans or washbasins), large beaker.

Strategy:

On the day before beginning the activity make sure the materials needed are available. If you do not have foodstuffs such as sugar, table salt, flour, baking soda, corn starch, etc., in the laboratory, you may wish to have students bring them from home.

Class activity:

1) The instructor will lecture to the class giving them examples of the various types of senses, smell, taste, hearing, seeing and touch.
2) Encourage student participation.
3) Allow student to practice at various stations attempting to prove their theory of which sense is most important.

Expected results:

The expected outcome of the five activities are such that the students understand that there is not a dominant nor non-dominant sense. In order to identify various sensations correctly you need all five senses.

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Reading a Weather Map

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Objective:

To enter the data from a weather report as it currently appears in the daily newspaper. The cities needed to make a comprehensive report should be preselected by the person recording in advance. There should be enough cities on the map to make an accurate report for your purposes. After the cities are entered, write the temperature for each city for that day. Draw very lightly, a line between each city with temperature of at least 10º. If you wish more accuracy for your area you may record a temperature of 5º difference for each line. For example, all cities with a temperature between 70º and 74º are between temperature lines of 70º and 75º. When completed the lines should form a contour of irregular or wavy lines. The contour lines should show a pattern of similar temperatures between the lines of temperature gradients, and across the entire country. To get a better picture of how a weather pattern moves and develops, a map should be made for at least 5 consecutive days.

Materials Needed:

The following materials are needed for each group of 5 students:
1) the weather page from a local newspaper for five consecutive days which gives the weather report from several cities across the entire country
2) a sheet of erasable tracing paper
3) a pencil with eraser
4) rubber cement
5) and if possible a small table or lab counter so that the group can all work together
6) a sheet of graph paper

One of the following is needed for the entire class:
1) an overhead projector
2) an transparency of a United States map with or without major cities
3) at least 4 different colored marking pens for transparencies
4) a transparency of graph paper
5) a transparency of previously plotted contour lines on the same map as above

Strategy:

INSTRUCTORS PREPARATION:
1) Plot and mark the desired cities on the transparency map.
2) Start the students off by drawing in at least one contour line, remembering that each student has a different daily weather record.
3) Go around the room working with each group to insure some degree of accuracy and participation.

CLASS ACTIVITIES:
1) Have students plot the location of the desired and/or missing cities.
2) Mark the high temperature for the cities from the weather data chart on their copy, as near as possible to the cities plotted on their maps.

3) Have students plot a line first by separating each city by temperature range in 10º Fahrenheit.
4) Try to connect lines of similar temperature as much as possible.
5) If there is a void over a large area or the lines do not seem to connect seek additional data for missing cities by checking another newspaper or contact the teacher.
6) Students then will choose one city and construct a bar graph of both high and low temperatures for a 5 day period.
7) Compare and/or observe this graph against that of another city and discuss the value of collecting weather data from more than one city.

Conclusions:

This activity is designed to show the value of collecting weather data from all over the country and how this data is used to construct a weather map. Then, using the data for an single location, make a 5 day forecast. The student could be shown how to enhance their map with the use of colored pencils or crayons.

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Vectors Via the Calculator (For Non-Math Students)

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Objective

To be able to resolve vector problems without knowledge of algebra or math. Give the student with poor math a chance of passing the course.

Apparatus Needed

Scientific Calculator with Sin, Cos, and Tan.
A Ball of yarn for demonstrating vector-Soft so as not to hurt a student hit with it.
Optional Overhead and overlay of vector-triangle.

Recommended Strategy

First, using the yarn tossed to the class, demonstrate the difference between regular and polar coordinates and that a vector must have a vertex and an angle. A sign on the string may help define the vector.

Next, use a worksheet that explains the steps of using the calculator. (Caution there are some calculators that you enter sin then the angle, where on most you enter the angle and then the function.) Be sure to include the use of the bracket (-). Also before demonstrations, check your calculator to be sure it is in the correct mode by using a known angle i.e., 30 degrees.

DO NOT USE the Pythagorean theorem, but use the Trig functions.

Demonstrate resolving two (or more) vectors using the Horizontal, --saving in memory--calculating the Vertical, dividing, and using the arc-tan to get the angle. Vector A is 2 units at 30 degrees, Vector B is 4 units at 120 Degrees. Find the resultant angle, and length. ----Be sure the memory is cleared----Save Horizontal in memory---
((2(30Cos))+(4(120Cos))m+Divide(2(30Sin)+(4(120Sin))ArcTan
Gives the angle now to find the magnitude
(Write down the angle found)
Using the trig formula R = Adj / Cos Find R
Mr divided angle previously found Cos = Vector Magnitude.

Have the student copy an example as it is worked out for his own notes. A pass out sheet double size 11 x 16 with references and examples functions well.

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Calorimetry

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Objectives

1. To learn basic principles of calorimetry.
2. To recognize the large amount of energy stored in food.
3. To learn to solve problems associated with calorimetry.

Equipment and Materials

2 Aluminum pop cans
3 small wood or sheet metal screws
1 paper clip
1 peanut half
1 thumb tack

Recommended Strategy

Construct a simple calorimeter by punching three holes in the bottom rim of a pop can equal distances apart and inserting the screws. Now put a hole in the bottom of the same can by sectioning the aluminum and bending it inward. Next drill a hole through the bottom rim large enough to allow a paper clip to be passed through. Finally, cut a rectangular port hole in the can about one inch from the bottom rim. The other pop can should fit snugly on top of the inverted burner pop can at this point. Now measure out a known amount of water and pour it into the whole pop can and record its temperature. Next mass and puncture a peanut half (dry roasted won't work as well) with a thumb tack. With the hole started, impale the peanut on a stretched out paper clip. Remove the peanut, hold it in the center of the top of the burner can and insert the paper clip through the hole in the can and the peanut, resting the end of the clip on the rim of the can. Place the can with the water on top of the burner can and ignite the peanut with a wooden match using the port hole for access. Let the peanut burn out completely and immediately record the temperature of the water. You can now make various calculations and determine the calories released by the peanut, calories per gram of peanut and even a percent error using a known value for peanuts which can be found in a calorie counting table.

Heat given off by peanut = mass of H_2O X change in temp of H_2O X specific heat of H_2O

The short form of the equation is $Q = m*dT*C_p$

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10Huh?

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Objectives:

To give students some practice at making **reasonable** estimates.

Apparatus Needed:

A good imagination.

Recommended Strategy:

Listed below are a series of questions which probably cannot be easily answered directly but where an answer to the nearest power of ten can, with some 'educated' guesses, be arrived at. (By nearest power of ten, is the answer closer to 10^1(=10), 10^2(=100), 10^3(=1000), 10^4(=10000), etc.) In each of the following questions, parts in square brackets [] represent something that should be replaced with a specific part or object peculiar to your school. It is good practice to have the students explain how they arrived at their answers since there can be some very creative ways of interpreting the questions.

Example: Question - To the nearest power of ten, how many times does a car tire go around while driving to Florida?
Answer (or how to get close) -

	Estimates	actual
distance (miles)	1500	about 1200 to the center of the state
feet per mile	5000	5280
feet for 1 tire rotation	10	about 10 depending on car (3.14 X 2.7)
	750,000	630,000

(rounded to 1,000,000 or 10^6)

To the nearest power of ten, how many:

1) total times does a toilet paper roll go around while the paper is being removed?

2) blades of grass are there in [pick some bounded area they can see from the window]?

3) floor tile are there in the building you are currently in?

4) telephones are there in the city of Chicago?

5) teeth are there in the school building on the average school day? (creative students may include comb, zipper and/or gear teeth)

6) light bulbs are there in the school? (are fluorescent tubes bulbs?)

7) automobile tires are there in Chicago on the average week day?

8) street lights are there in Chicago?

9) leaves on the average tree? (ask in spring or early fall)

10) molecules in the average human body?

11) seconds does the average American live?

12) letters are there in your text book? (creative students may answer 1 - 26 to the nearest power of ten i.e. 10^1- 26 is WRONG since it is either not a power of ten or there are more letters than in the entire library - 10^{26}!)

13) books are there in the school library?

14) steps does the average student take while moving around in the school on the average school day?

15) hairs on the average house cat? (or dog or human head)

16) millimeters high is the school?

17) snow flakes are covering the [pick an area they can see from the window]?

18) black ants does it take to fill a bath tub? (careful about asking this question verbally since creative black students may answer 1 (or 10^0) thinking you mean aunt instead of ant!)

19) stair steps to the moon?

20) sheets of paper are used in the school during the average school year?

21) ping-pong balls does it take to fill the classroom? (basketballs, human heads, etc.)

22) ice cubes could you make if you froze lake Michigan?

23) grooves are there on a 33.3 rpm record that plays for 20 minutes on each side? (10^0=1 - there are really 2, one on each side but to the nearest power of ten, the answer must be 10^0 (or 1))

24) gallons of water fall on Chicago in an average thunderstorm?

25) keys are there in the school on the average school day? (including keys on calculators?)

A real zinger for creative students - To the nearest power of ten, how many students in the school are BOTH male and female? (If they answer 0, 10^0=1 and that means they are answering that one student is both male and female! They really should answer negative infinity since the only way to get zero is to have $10^{-infinity}$.)

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To Construct An "ALTITUDE LOCATOR" To Find the Height of the Building, Height of the Tree and Height of Any Given Objects

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Objectives:

To learn to define the terms like Altitude, Ratio, Proportion, Similar triangle.
To learn to construct an "Altitude Locator"
To use Altitude Locator to find the angular distance of the Building and the angular distance of the tree.
To construct the similar triangles and determine the height of the building and the height of the tree.

Apparatus needed:

Construction paper, glue, scotch tape, stapler, scissors, strings, paper clips, straws.

Procedure:

Glue the copy of the protractor to the card board and punch a hole in the middle of the Ruler side. Hang a paper clip through the string and pass it through the hole in the protractor. Paste a straw on the ruler side horizontally using the glue or the scotch tape. Look through the hole of the straw to locate the top of the building or the top of the tree and measure the angle of elevation E. Also measure the distance from the base of the object to the person B1. Find the height of the person from the ground to the Eye-level h1. Construct a similar right angle triangle with same angle of elevation.

```
      A
      |\
      | \
   T  |E \                                  D
   R  |   \
   E  |    \                                |\
   E  |     \                               |E\
    H1|      \                              |  \
      |       \                             |   \
      |  O     \                          H |    \
      |90       \                           |  O  \
    K ------------ C                        |90    \
      |     B1   |                          |--------
      |          |                        F     B     G
```

```
      |        h1|
      |          |
      ------------
```

Right angle triangle AKC is similar to DFG(Construction).
Angle KAC=FDG(Construction).
Angle AKC=DFG(Right angle).

```
         Therefore   H1   H
                     -- = --
                     B1   B

                     H1 = H (B1)
                          --
                          B
```

If B1=23.3 meter and B=10 cm. and H=5 cm., h1=1.52 m.

```
                          5cm.(23.3 m)
                          --------------=11.65m
                           10cm.
```

```
H=H1+h1
  11.65+1.52=13.17m.
```

Therefore the height of the tree is 13.17 meter.

We can also find the height of the building using the same method.

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Measurement

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Objectives:

Given the meter as an initial unit, the student will be able to see the value and relationships of units less than and greater than the meter.

Students will be able to choose the appropriate unit of measure in relation to the linear distance required to measure.

The student will measure within one tenth or less accuracy with each instrument.

Students will be able to show by plotting on histograms linear relationships.

Materials:

Cuisenaire rods, tennis and superballs, string, ten metersticks, tape measure (various size measuring utensils are optional), graph paper about 1 cm square, and stop watch.

Strategies:

Mark off four to five stations labeled A, B, etc.

Station A student will determine his or her time walking a distance of ten meters and record that time.

Station B student will measure arm span versus height. Write in on chalk board and graph when this is complete for the class.

Station C student will test his/her ability to jump horizontally. One student jumps and another makes a mark where lead foot lands and measure in centimeters and record.

Station D student will guess their head size and then measure with tape measure. They will also make comparisons of the sizes of utensils in relation to teaspoon, tablespoon and cup. All of their data are recorded and later compared.

At the end of this activity, students will write a poem or make a rap song about the activity.

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Using A Video Camera In the Physics Classroom
(In this case to find the value of "g")

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Objectives:

To use equipment that is interesting to the students (a video camera and a VCR) as a data gathering tool.
To use the video tape produced in analyzing and understanding motion.

Apparatus Needed:

1. Video camera on a tripod, VCR with "freeze frame" capability and one **new** blank video cassette.
2. Two or three meter sticks.
3. A large, heavy object to drop (needs to be easily visible and not significantly effected by air friction).
4. An effective timing device accurate to hundredths of a second, preferably something that can be clearly seen on the video screen.
5. Five or six plain sheets of paper.

Recommended Strategy:

Tape the meter sticks vertically on the wall end to end and tape the sheets of paper next to the meter sticks every half meter. Beginning at the top sheet draw large heavy lines each half meter and label them appropriately (0, .50, 1.00, 1.50, etc.) These will serve as visual distance reference points on the video screen as the object is dropped.

Look on the video screen and make sure that the whole vertical drop and the stopwatch are visible without camera motion. Start the video tape recorder in the "record" mode. Start the stop watch running. Have someone in the video picture visibly "count" (by raising and lowering their arm) "1, 2, 3" and on "3" another person will drop the object from the "0" meter mark (the bottom of the object should be at the mark.) After it has fallen, stop the video recorder and rewind to the starting point. You should have a video tape recording of the experiment.

Two quantities must then be observed: the distance (d) the object fell and the time (t) that it took to fall that far. Look at the tape which you have made and attempt to freeze frame the object **just** as it is released. This will take many attempts unless your video recorder has a feature which allows you to step through the tape frame by frame. When you believe you have the object frozen as close to the instant of release as possible, note the time (t_0) showing on the stopwatch. (If you have trouble reading the stopwatch it is probably because you are using a portion of the tape which has previous material recorded on that segment. You must use a previously unused portion of tape to see clearly.) Now advance the tape to a "freeze" position where the distance fallen (d) is easily "seeable", probably at a place on the large sheets of paper, and note the time (t_f). Again, it will probably take many tries to stop the tape in a position where you can be sure of the distance the object has fallen and the time it took to fall that far unless you have frame by frame capability.

The only further work left is calculation. Time (t) = $t_f - t_0$. Now substitute the values of "d" and "t" into the equation for uniform acceleration of an object from rest "g" = $2\ d\ /\ t^2$ and you have a value for the acceleration due to gravity. I would ask the students to state how certain they are of their results using this method.

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A Potpourri of Science Ideas

Group Mini Teach

Finding Pi

Foreman, Dorothy Joplin School

Objective:

To measure the circumference and the diameter of various cylinders, and to use the ratio C/D to find pi.

Apparatus Needed:

metric rulers, string, graph paper, tape, cylinders of various sizes.

Recommended Strategy:

Roll the cylinders one complete revolution and measure the distance traveled. Use string to measure the diameter. Make a data table. Make a pi graph. Use the pi graph to calculate the constant ratio pi. (Students should discover a direct proportion between the variables).

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Computerized Problem Review

Mini Teach Group Summary
Donna Allen
Joytiben Desai
Albert Oldenburg

Objectives:

To summarize the concepts of distance, velocity, vectors, and acceleration. To develop the methods of the problem solving and specific techniques. To give the students a form of computerized problem review.

Materials:

Notebook paper, pencil, chalk, T-V monitor, VHS recorder, several sheets to be handed out (data necessary for ten problem repeats for each problem).

Strategy:

I. Perspective and Update

A. The students became acquainted with and somewhat proficient in l;measuring length, area, volume, time, mass, and various units of each. Also vectors, scalars, error analysis, significant figures, scientific notation, computer notation, orders of magnitude, graphing, direct and inverse proportions.
B. The students have outlined the chapter(s). A form and procedure were given.
C. Lectures and discussions were presented and developed.
D. Quizzes were used to encourage and enhance their concept knowledge (10-20 questions, T,F, or multiple choice scantron, 10-15 min).
E. Experiments are used as a hands on first hand experience of the concepts and their interactions.
F. The examples of the problems are to abbreviate and quantize the concepts, and also to show how they work together are developed during our lecture and discussion periods.
G. A problem assignment is then given the students. In this case problems 1-7 page 47 were assigned.

II. Procedure for Solving Physics Problems

A. From some previous experience in solving any word problem and most physics are word problems, we know that there are key words and tricks to get them solved.
B. O.K. now what are the key words in the first problem, in order? Write them down on your paper.
C. Trick 1. Now since physics problems are similar to math problems we will use the first letter of each word to represent that word like an abbreviation of that word and label each number that we know from the problem.
D. Trick 2. What letter or letters don't we know or have a number

for? Write these down also.

E. Trick 3. How does this unknown letter work together with the known letters?

F. If we are stuck here we could go back to our definitions of our vocabulary to help us out and refresh our memory.

G. In order to keep the problems organized I would like the student to use this simple form from now on in physics.

(page no.),(problem no.)

47-1. Given: (diagram included),(equation form definitions)

Eqn:

Subst:

Ans/units:

H. After this the problems 1-7,pg.47, are assigned for the next day.

I. These problems are handed in the next day. Then I present the students with a ditto sheet of a repeat of from five to ten problems for each problem of the text book assigned problems.

III Computerized Review

A. A computer with a monitor is set up for use in front of the classroom.

B. A program is loaded into the computer and made to appear on the monitor.

C. This program is our review program for doing the problems on page 47 (text) in this case.

D. At this point a student may be asked to operate the computer with the teacher's guidance to enter the appropriate responses.

E. Briefly the program consists of (in basic) a looping statement (to repeat the problem four times), several input statements to input data for the specified problem, an equation to solve the problem, an output print statement to visually see on the screen the answer to the problem, then a next statement to repeat or go back and redo the same problem as many times as the "FOR" statement declared.

F. Then we take the firs four of these problems and develop them according to our physics problem solving procedure on paper concurrently while developing them on the computer monitor screen.

G. We then compare the student papers with the computer monitor screen to see if we are on the right track.

H. After three repeats of each problem, that is each student is writing down the given, equation, substitution, answer/units for each repeat, we move on to the next problem.

I. We then do as many problems with three repeats as time permits.

J. Just before the bell rings I tell the students that they can do as many problems from the ditto sheets as they can and they are to be turned in as more homework problems with certain amount of credit attached.

K. The chapter or unit test is usually predetermined and occurs on the day the problems are handed in.

L. The problems are handed in upon entering class and the students usually seat themselves quietly and quickly to proceed to take their test.

IV. Conclusion:

A. When the students have the opportunity to do this computer review their test scores typically are two to three times those of comparable tests taken without the review.

B. Nearly all the students that participate enjoy and look forward to doing these computer reviews.

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AN ALTERNATIVE TEMPERATURE MEASUREMENT

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OBJECTIVES:

Show: (1) alternative method of temperature measurement, (2) thermal expansion of gasses.

EQUIPMENT:

500 ml flask, ring stand, test tube clamp, half-meter-long glass tube, one-hole rubber stopper, thermometer, beaker, graduated cylinder, 2 lb coffee can (or other container large enough to hold sufficient warm water to cover the flask), stamp pad ink or other water coloring substance.

STRATEGY:

This is probably best done as a demonstration, at least for the first time. Fill the beaker mostly full of water, and add enough coloring to make water in the glass tube clearly visible. Insert the glass tube into the stopper. Fill the coffee can with water at about 30ºC, and hold the empty flask almost completely under water with the test tube clamp. Put the stopper in the flask with perhaps 35 cm or so of the glass tube sticking up out of the stopper. Measure the temperature of the room as exactly as possible, and then after perhaps 5 minutes, carefully measure the temperature of the water. Now place a wet finger over the end of the tube and then remove the flask, tube, stopper and all, from the coffee can. Immerse the open end of the tube in the colored water in the beaker, and then remove your finger. Finally, place the neck of the flask in the test tube clamp so that you don't have to stand there holding it and looking foolish. As time passes, the colored water will climb slowly up the glass tube toward the flask.

The exact form for discussing this phenomenon will of course depend on both the instructor and the class. Students might be asked why the water rises, for example. When temperature is suggested, perhaps the class could be asked whether the flask warmed up or cooled off as the water rose. After this, a student might wish to test the temperature of the water in the coffee can with a finger, and then put a hand on the flask to see whether the flask is warmer or cooler than the water. Because of the relatively small difference between the two temperatures, it may be necessary to reveal both the initial (warm) and final (cold) readings of the flask temperature. While the student holds his or her hand on the flask, it may be observed that the water height decreases, and the class may again be asked for the reasons. If more than one is suggested, the students may be asked to propose experiments that might determine what the most important factor actually is.

The class may wish to use the device to measure relative temperatures of the hands of different individuals. If they do, it should be suggested that they determine afterward whether the height of the water at room temperature is still what it was in the beginning. (It won't be, in all probability.)

QUANTITATIVE TREATMENT of the topic turns out to be decidedly non-trivial, and is **not recommended** for most high school classes. If one or more advanced students wish to try, however, the example below uses results obtained during a trial in the summer of 1986. The capacity of the flask with the stopper inserted was 541 ml. The glass tube (one of unusually large diameter) was 48.3 cm long and, when full, held 18.5 ml of water. Room temperature that day was 21.6ºC, and the temperature of the warm water was 28.3ºC.

The colored water rose 17.7 cm in the tube while the flask was inverted. Allowing 2 for the air in the tube, the warm volume was thus about 554.4 ml. Atmospheric pressure is normally about 76.0 cm of mercury. Since we were using water, and mercury is about 13.6 times as heavy as an equal volume of water, normal atmospheric pressure would be about 1034 cm of water. Initial warm volume would thus be about 554.4 ml, and final cold volume would be 547.6 ml. It would seem that the Ideal Gas Law should apply, especially over such a small temperature range. If it did, then we could use the Ideal Gas Law equation

$$P_H V_H / T_H = P_C V_C / T_C,$$

where P=pressure, V=volume and T=temperature **on the Kelvin scale**. Then assuming the original pressure to be atmospheric pressure, we could calculate the final pressure. Using the values supplied above, the result is 1023.56 cm of water. On reflection, however, this just can't be. The atmosphere actually provides not only the pressure on the air inside the flask, but also **enough to support that 17.7 cm of water** as well. The actual pressure on the air inside the inverted flask must therefore be **less** than 1034 cm of water by 17.7 cm, or 1016.3 cm of water. What's wrong?

The main culprit is the fact that water vapor (from the moisture of the stopper, flask, tube, etc.) is by no means an ideal gas, and it therefore does not follow the equation given (although air works quite well). The **Handbook of Chemistry and Physics** gives the vapor pressure of water at 21.6ºC as 19.349 cm of mercury, and that of water at 28.3ºC as 28.848 cm of mercury. Since water vapor pressure at room temperature made up 2.59% of the 1016.3 cm of water (74.70 cm of mercury) that was the total pressure, then the same percentage of the contents of the flask must have been water vapor - which would come to about 14.18 ml, leaving the volume of air as only 533.4 ml at room temperature. Similarly, using the actual warm pressure of 1034 cm of water (or 76.0 cm of mercury) and the actual combined air-and-vapor warm volume of 554.4 ml gives us a volume of warm water vapor of 21.04 ml, almost 50% more. This means the volume of warm dry air was really 533.36 ml, virtually unchanged despite the difference in temperatures!

Using 533.4 ml as the volume of warm dry air and the gas law, along with the reduced pressure after cooling, we find that the final volume of the cold dry air alone **should** have been 530.6 ml. This, added to the 14.2 ml volume of water vapor, would give a final volume of 544.8 ml, instead of the 547.6 ml actually observed. Considering the volume-per-centimeter of the glass tube, that would mean that the water should rise about 7.3 cm **more** than it actually did.

The latter figure is not entirely accurate either, however. If the water in the tube rose further, the pressure would have been lessened and the total volume of the cold sample increased because of that reason, and thus the deficiency in height would be less. Further, as time went on, the height of the water in the tube dropped visibly, indicating some leakage in the system. Additionally, the original and final temperatures were measured only indirectly and may not have been entirely accurate. During the demonstration, a calculation based upon the coefficient of linear expansion of Pyrex glass indicated a negligible effect.

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PERSISTENCE OF VISION

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OBJECTIVES:

1.To build a persistence of vision model of flying birds.
2.To relate this model to persistence of vision in viewing movies.

MATERIALS:

1. Assorted short strips of movie film.
2. Two slotted circles duplicated on stiff paper.
3. One set of eight birds in various positions of flight.
4. One blunt pencil, four strips of masking tape,one sharp scissors.

STRATEGIES:

Give each student a strip of movie film and have students observe the individual frames.

Distribute materials for the flying birds model. Have students cut two slotted circles and eight slotted bird pictures. Wrap a few turns of masking tape near the blunt end of a pencil. Place one of the circles over the blunt end of the pencil and secure with tape.

Slide the top of bird picture #1 into one of the slots in the circle. Tape the second circle to the pencil so that the lower slot of #1 bird fits into a slot in the second lower circle. Insert birds #2 to #8.

Have your students rotate the flying birds. Ask them to explain why the birds appear to fly.

Refer to the strip of movie film again. Have your students relate the persistence of vision phenomena of the flying birds model to the movement caused by changing frames of film in a movie.

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-SMILE-

Science and Mathematics Initiative for Learning Enhancement

The SMILE program is designed to enhance the elementary and high school learning of Science and Mathematics through the use of the phenomenological approach. For a brief course description/syllabus click here.

Between 1986 and 1997 each summer session participant was asked to create and publish a single concept lesson plan. These lesson plans include the materials needed, a suggested strategy and expected outcomes. There are currently almost 900 of these lesson plans available (see subject indices below). In addition, starting in 1997 the participants in the academic year program have been asked to present a brief single concept lesson or idea. Summaries of the academic year lessons are at academic year notes. All of these lessons are available in the following formats:

1. A book of each summer's lessons. The cost of a book of all of the lessons developed during a single summer is $10.00. Contact Dr. Porter Johnson (312) 567- 5745, Dr. Ken Schug (312) 567-3438 or the departmental office at IIT (312) 567-3480 for availability.
2. A CD-ROM with all of the lessons (summer and academic year) and links from both this and the SMART web sites for $15.00US to a US address ($20US outside the United States). Contact Roy Coleman at Morgan Park High School (773) 535-2550 for availability.
3. Listings by subject are available by linking to any of the following:

Biology Chemistry Mathematics Physics

Awards and Reviews

Education Planet	Schoolzone International	NSTA Scilinks

StudyWeb	Big Chalk	Actionbioscience
Wired Patrol	Psigate	Schoolsnet

NOTE: If the following looks really bad or your browser doesn't support tables, try the old home page.

If you have a single concept lesson that you think might fit in with the SMILE concept or would like to see some lessons which have been contributed by persons other than SMILE participants jump to contributed lessons

SMILE has bi-weekly classes during the academic year and we are posting the notes from those classes. If you are interested, jump to academic year notes.

The SMILE PLUS program is a program designed for intensive training of a team of teachers who are from the same school. These teachers then go back to their home schools to provide inservice training for the remainder of the faculty and staff.

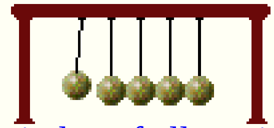
This section includes some general information developed by the SMILE program.

- Information on Science Fairs: How to start and run a Science Fair, Chicago Public Schools Science Fair information and NEIU's Science Fair Central.
- Sources of reference material
- Sources of hands on science equipment in the Chicago area

Photos of the 1997, 1998, 1999 and 2000 SMILE participants in action.

Web Addresses of internet sites for general interest in Science. IIT will occasionally offer Saturday classes for teachers and students on the World Wide Web and searching the Internet. For more information, contact Dr. Porter Johnson

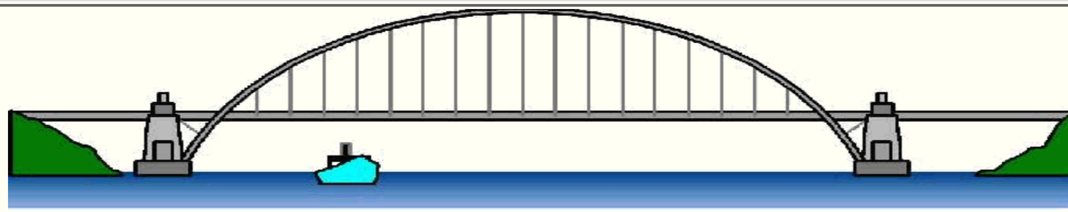
Fall 2004 schedule of classes.
First class and registration will be September 14.
Visitors are welcome to sit in on many of the classes.



The entire index of all sections is also available for you to search with your browser. However, be aware that this index is about 100K and takes a while to transfer.

 Additional lessons can be found on the SMART website. 

The SMART program is made possible by a generous grant from the Lucent Technologies Foundation.



Information on the High School Bridge Building Contest is available at the 'hsbridge' website.

NOTE: The area code of most of Chicago is now 773. IIT, however, is still in the 312 area code.

Email address: smile@iit.edu

Address: Smile Program - Dr. Porter Johnson
IIT-Dept of Biological, Chemical and Physical Sciences
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You are visitor 272502 since March 1, 1997.
Please sign our visitor's book.

Last update Monday, May 31, 2004 by Roy.Coleman@iit.edu

Animation courtesy of http://www.dewa.com/animated and http://www.iconbazaar.com

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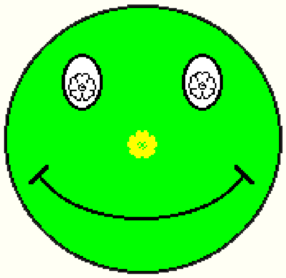
<td>
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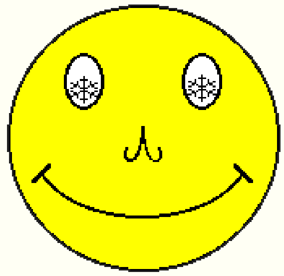
<td>
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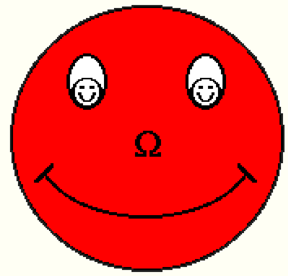
<td>
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Charles Buzek - John Spry School

Gathering data about respiration

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John Spry School
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Objective(s):

To provide a means for the student to collect data which will further allow the student to analyze that data for the purpose of drawing conclusions.
To initiate in the student the need to design instruments for scientific inquiry and develop an appreciation for the accuracy of such measurements.

Materials Needed:

Balloons, rulers, and a conversion chart for cubic inches

Strategy:

This activity should be prefaced by a brainstorming session in which the students and instructor break down the various divisions of respiration. The students should arrive at three discrete events which can be used to collect data about the breathing process. These events will answer the following questions: 1) How much air do we breathe out normally? 2)Is there any air left in our lungs after we breathe normally? 3) How much is actually in our lungs when we breathe normally? These questions will lead to the following activities:

1) the subject will breathe normally then expel that air in a normal fashion into the balloon. The balloon will then be measured across its broadest part with a ruler.

2) the subject will breathe in and out normally then expel all remaining air into the balloon, exerting as much pressure on the lungs as possible to push out any remaining air. Again the balloon will be measured as above.

3) the subject will breathe in normally, then try to expel all the air that is in their lungs. Again measure as above.

These tests will provide the student with data concerning three aspects of the respiration process. At this point another brainstorming session is in order. What does the data tell us in isolation? Do we need to obtain data from a larger sample? How should that sample be constructed? Do we need to frame special questions relative to the sample group e.g. how do men and women compare in terms of respiration? Is there a size factor? These questions or others will determine how a sample group should be constituted.

Performance Assessment:

The instructor examines the data with the understanding that the measuring device is crude and will deliver data of varying quality. The students will construct a chart which delineates the information for their sample. Then the student will formulate a theory based on the data they have obtained. The student's successful accomplishment of the activity will be determined by how well the data fits the theory.

Conclusions:

This activity ought to be seen by the instructor as only incidentally being concerned with respiration. The emphasis in actuality is on experiment design and interpretation of data. These activities form the backbone of scientific inquiry and should collaterally be the foundation of science instruction.

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Biology/Chemistry

Production of Sound

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Objective(s):

1. Define the word sound
2. Compare/identify high and low pitches
3. Identify the vocal human anatomy
4. Classify the various forms music sound production

Materials Needed:

The teacher will need the following: overhead projector, chalkboard, transparency of *Anatomy involved in Vocal* Production, straws, scissors, speaker amplifier, and soprano recorders (instrument).

Strategy:

Step 1

Students will be given an explanation of the transparency of Vocal Anatomy. Instructor will give an explanation on the following: 1) vocabulary ----pitches, diaphragm, posture, lungs, brain interpretation, ears, etc. 2) demonstration of the vocal chords, 3) location of the anatomy that enables people to make sounds and 4) understanding and demonstrating frequency and vibrations.

Step 2

Instructor will hand out straws and scissors and instruct students to cut the straws into 3 different lengths. The students will then blow their breath over the opening and will discover (hopefully) that the length affects sound.

Step 3

Using a dummy microphone, students will learn to project, articulate and enunciate their voices. (This can be part of the lesson or can be done as enrichment activity). **Please note** that microphones can be researched and microphones can be created through an art project.

Step 4

Each student will be given a recorder (instrument). Instructor will discuss the mechanics of the instrument. The instructor will demonstrate how vocal anatomy is used to play this instrument.

Step 5

Instructor will demonstrate and teach the students how to play a simple tune on a recorder.

Performance Assessment:

The students will be able to:

- discuss the parts of the vocal anatomy that help to produce sound.
- fill in the name three parts of the vocal anatomy and their location on a human body worksheet
- will be to perform using their straw instruments high and low pitches
- will be able to perform on their recorders Three Blind Mice
- write definition of sound

References:

Curriculum Guide for General Music Chicago Board of Education, Copyright 1989

Lee, William. ***Belwin New Dictionary of Music.*** Publishing Company Belwin Mills, 1989.

Biology/Chemistry

Feely Balloons

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Ravenswood School
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Chicago IL 60613
(773) 534-5525

Objective:

Students investigate unknown solids using the sense of touch

Materials Needed:

3-5 small zipper type plastic bags or baby food jars,

3-5 uninflated balloons (each of a different color)

Wide-stemmed funnel

3-5 types of solids with which to fill the balloons such as the following: rice,

beans, salt, powder such as flour and corn starch

Strategy:

1. Instruct students to use their senses (except taste) to investigate the set of balloons and answer Questions 1 – 4 on the "Mystery Solid" Observation Sheet (provided).
2. After ample investigation time, have the groups record what the thing is inside each balloon on the Observation Sheet.
3. Call on each group, asking the spokesperson to tell what the group thinks the contents are and to provide some supporting evidence for these conclusions.
4. Ask students what they might use to make the task of identifying the balloon contents easier, but remind them that they still cannot open or cut the balloons. After discussion, give each group a set of reference containers, telling them that the reference containers hold the same materials as the Feely Balloons
5. Ask students to match balloons with sample containers and record their matches on their Observation Sheets.
6. Reveal the actual contents of the balloons by cutting open one of the sets of balloons and allowing students to examine the contents.

Performance Assessment:

Partner pairs of students. Direct each student to explain to their partner how they made their decision about which solid was in the balloon.

References:

Teaching Science with Toys, 1993

Biology/Chemistry

Investigating the Nervous System

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Doolittle West Primary
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Chicago IL 60616
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Objective(s):

To investigate which end of an earthworm is more sensitive to odors, light and sound. This lesson could be used for students who are kindergarten through seventh grades.

To investigate why you can't tickle your own foot

Materials Needed:

Paper towels, cotton swabs, flashlights, nail polish remover, vinegar, earthworms and graph paper

Strategy:

SOUND

After placing the earthworms on a paper towel, students will work with a partner to investigate how earthworms respond to stimuli like snap of the finger, clap of the hands, singing the scale in a high pitched voice as well as a low pitched voice. One partner will be responsible for recording what reaction the earthworm made to each of the above sounds. The above steps would be repeated with the other partner recording.

LIGHT

An investigation of how the earthworms respond to the flashlight rays beaming on the front and the rear of the worm. The responses will be again recorded on the graph paper.

SMELL

Dip the cotton swap in nail polish remover. Place the swap near the worm's brain, middle of body and the end of the worm. Record the responses. Place some vinegar on the other end of the cotton swap. Now place the vinegar soaked swap near the worm's brain, middle of body and the end of the worm. Note and record what responses occurred.

Performance Assessments:

The oral discussion will illustrate that the students understand the earthworm has no eyes, that is why there was no response to the flashlight on any part of the earthworm's body.

Reading and interpreting the graph on the responses of the earthworms to various sounds.

The earthworm does not a nose but they have a nervous system that responds to stimuli such as odors.

Students will draw the brain, nerve cord and nervous system of the earthworm by looking at the handout.

They will explain why when the worm is cut in half both sections of the body continues to move.

The answer is each body segment also has a mass of nerve tissue that controls activities within the segment.

References:

200 Gooey, Slippery, Slimy, Weird and Fun Experiments. Page 34 by Janice Van Cleave Henry's Sports & Bait Shop, 3130 S. Canal Street, Chicago, IL 60616

What Happens When You Eat?

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Lincoln-Way High School
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New Lenox IL 60451
(815) 485-7655

Objectives:

These activities will show students what organs aid in digestion and how digestion occurs in the human body. This lesson maybe appropriate for middle grades, but is designed for the upper grade curricula.

Materials Needed:

Activity #1: How Long is the Digestive System?
- yarn (at least 4 different colors)

Activity #2: Digestion
- sugar cubes
- granulated sugar
- 2 clear cups filled with water

Activity #3: Carbohydrate Digestion
- unsalted soda crackers (2 per student)

Activity #4: Hands on Digestion
- a small lump of hamburger (meatball size)
- one plastic baggie
- 1M HCl
- Digestive Juice A (pepsin, trypsin and water)
- Digestive Juice B (bile salts, pancreatin enzyme and water)

Activity #5: How do Villi aid the Small Intestine in Absorption?
- paper towels (10 per group)
- 4 cups of an equal amount of water
- graduated cylinder

Activity #6: A Digestive System Simulation
- large thin plastic bag
- paper sacks (2 sizes)
- M&M's candy
- markers & paper
- trash can
- newspaper
- Zip-lock bags
- masking tape
- sponges
- labeled spray bottles of water

Strategy:

Activity #1: How Long is the Digestive System

Have students cut a piece of yarn according to the following measurements. Allow students to use different color yarn to represent different organs. After the yarn has been cut tie the pieces together.

Esophagus	25 cm
Stomach	20 cm

Small Intestine	700 cm
Large Intestine	**150 cm**
TOTAL	895 cm

Activity #2: Digestion

Place a sugar cube in a cup of water. Place about a spoonful of granulated sugar in the other cup of water. Observe what happens.

Activity #3: Carbohydrate Digestion

Have the students chew two unsalted soda crackers for two minutes without swallowing.

Activity #4: Hands on Digestion

Place the hamburger, 3 eyedroppers full of 1M HCl, one tablespoon of Digestive Juice A and two tablespoons of Digestive Juice B into a plastic bag. Knead the bad with your hands (simulates the stomach) for about 10-15 minutes, it will have been reduced to mainly liquid and have a definite odor.

Activity #5: How do Villi aid the Small Intestine in Absorption?

Compare how 1, 2, 3, and 4 folded paper towels absorb. Dip each paper towel into a cup of water (use the same amount of water in each cup). Record the volume of water left in the cup (using a graduated cylinder).

Activity #6: A Digestive System Simulation

Procedure:

Things to make ahead of time:

1. FOOD TUBE: Lay out two parallel lines of tape on the floor, 3' apart and long enough for half the class to stand shoulder to shoulder on one side of the parallel lines.
2. FOOD PARTICLE: The food particle consists of M&M's placed in small zip-lock bags. These are placed in wadded newspapers in small paper sacks. Place the small sacks in larger sacks with added newspaper. Place all sacks and add newspaper until the large plastic bag is full. This bag is then taped or tied closed to complete the food particle.

Action:

1. Peristaltic Movement: Put the food particle to be eaten at one end of the food tube and a large trash can at the other. Have students line up on both sides, facing each other, squeeze the food particle the length of the food tube.

2. Digestion: Label and/or instruct the players. As the food comes to a student they should narrate what they are doing and why.

   Teeth - tear food apart (break plastic bag)
   Saliva - use spray bottles to moisten food particle
   Stomach - tear small bags apart
   Pancreatic juices - spray food
   Small Intestine - absorbs food, find bags of candy and pass to blood (the teacher can play the role of the blood)
   Large Intestine - reabsorbs water, sponge up water on the floor
   Rectum/Anus - puts the waste papers in the trash can

Performance Assessment:

At the completion of this lesson students should be able to answer the following questions:

1. What system in your body is the same length as the completed piece of yarn? What is it's length (in centimeters, in feet)?
2. From your observations in Activity #2, what can you conclude must be done to food before digestion begins?
3. What physical and chemical changes occurred to the soda cracker?
4. What caused the physical and chemical changes to the soda cracker?
5. Did you notice a taste change in the soda cracker?
6. How was mechanical digestion simulated in Activity #4.
7. What evidence was their that chemical digestion occurred in the hamburger?
8. Which paper towel had the largest surface area?
9. Which cup had the highest volume of water left?
10. How do the villi (of the small intestine) aid in absorption?
11. Follow the path of a food particle through the digestive system; include the organs and their functions.

Conclusion:

These six activities will enhance the student's knowledge of what organs aid in digestion and how digestion occurs in the human body. Students will have a more comprehensive understanding of what happens in their bodies when they eat.

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Taste, Smell, Touch

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Objective:

This lesson is designed for grades third through sixth, although it can be modified for any grade level. The objective is to compare and describe objects by using the senses of touch, smell, and taste, and to demonstrate more clearly how a single sense works by eliminating one of the other senses.

Materials Needed:

1 meter measuring stick
1 spray bottle of perfume (any brand)
dixie cups (number will vary depending upon class size)
hot water (not scalding)
ice cold water
vanilla extract
lemons or lemon juice (your choice)
plain water
vinegar
tonic water
Soda - Coke and Pepsi
Various fruits of different textures and flavors
Assorted items of varying textures i.e.; felt, fabric, carpet samples, piece of marble, sandpaper, leather, wood, etc.
straight pins or tweezers (depending upon age of children)

ACTIVITY #1: TOUCH

Strategy: Students will experience different sensations when the skin is stimulated by touch, pressure, heat, and cold.

To demonstrate the sensation of Pressure: Have the students place their index fingers together and push. The fingers will create a sense of pressure on each other.

To demonstrate the sensation of Heat and Cold: The students will place their fingers into two cups of water simultaneously, one cup of ice water and one cup of hot water. Observe the sensation that your body temperature will adjust to the temperature of the water after a few moments.

To demonstrate the sensation of Touch: Place items of varying textures into a bag or mystery box. Have students close their eyes (or blindfold them), and have them pick an item. They are to describe the item and attempt to identify it based only on the way it feels.

To demonstrate how well the touch sensors are able to distinguish two or more closely spaced objects: Cut three pieces of cardboard and push one straight pin into a piece; two into another; and three into a third. Have students gently touch each pin with a finger and try to determine the number of pins, one, two or three. Each child should be blindfolded or have eyes closed. If children are too young you may substitute with the tweezers.

ACTIVITY #2: SMELL

STRATEGY: Students will investigate both the acuity of the sensation of smell by sniffing various items, and how scents diffuse through air.

The instructor will place four bottles covered and labeled A, B, C, D on a table. Each bottle will contain one of the following liquids: vinegar, vanilla flavoring, lemon juice, plain water. The students will sniff each bottle and write down what they think the contents are. After all students have sniffed the bottles the instructor can tabulate the guesses on the chalkboard or on a wall chart. The accuracy of the student's guesses will depend upon previous experience. Once they have smelled a scent they will never forget it. If they have not smelled these scents they will have difficulty identifying the liquids.

To demonstrate the Rate of Diffusion of a scent: The instructor will hold a spray bottle of cologne and line up 4 students 2 meters from each other and on a straight line with the teacher as one point. The first student will be 2 meters from the teacher. The teacher will spray cologne vertically into the air (not in the direction of the students). Simultaneously, a helper will start timing using a watch with a second hand. When each student on the line first smells the cologne, they will call out; a recorder will record the time at which this happens. The data will be plotted as a graph of distance travelled by the cologne (Y-axis) versus time (X-axis). The rate of diffusion is the distance travelled/time. It can be calculated individually for each person (point) on the line and these values averaged. Also the diffusion rate is the slope of the line on the graph.
The equation: Rate of diffusion = Distance (meters)/ Time (seconds).

ACTIVITY #3: TASTE

STRATEGY: Students will experience the sensation of taste. The students will discover that the sense of taste and smell are integrated.

To demonstrate the sense of taste. The instructor will place fruit of various flavors into cups. Each student will be blindfolded and a partner will place a piece of fruit into his/her mouth. The student should pinch his/her nose closed for the first piece and try to identify the fruit. The partner should follow with the same fruit but the subject's nose should be open. Instruct the student to try to identify the fruit based solely upon taste. In other words don't identify a banana because you know how it feels in your mouth. It should be easier for students to identify fruits with their noses open.

The Coke and Pepsi Taste Test. The question is can you actually tell the difference between Coke and Pepsi? The instructor will place Coke and Pepsi into cups and label them A and B. The students will taste each and try to guess which is which. The results should be tallied and checked for accuracy. This exercise would work well with two liter bottles that have had the labels removed and are marked A and B corresponding with the cups. Math may also be integrated by using percentages. Create a circle graph and indicate the percentage of students that guessed A was Pepsi or B was Coke. This can then be extended to calculate the percentage of correct guesses.

To demonstrate the sensations of bitter, sweet, sour, and salty. The instructor should label cups A, B, C and D. The cups will contain tonic water, representing bitter; fruit juice, representing sweet; lemon juice, representing sour; and salt water, representing salty. The students will taste each solution and try to identify the location on their tongue where the taste of each solution was most prominent. The students should drink plain water in between tastings.

Performance Assessment:

1. Provide a picture of a tongue. The student will accurately identify the location of taste buds and the taste they represent bitter, sweet, sour, and salt.

2. Answer the following questions:

A. If you place a drop of honey or a sugar cube into your mouth, which food will stimulate the sweet taste buds first?

B. When the fruit was tasted with your nose closed it was more difficult to identify. Why?

C. When you have a cold your sense of smell is lost. Explain why?

D. When the human sense of smell is compared to that of animals whose sense of smell is better?

E. Which sensory receptors are stimulated by heat, touch, sight, and smell?

F. Was it more difficult to identify objects by touch only than it would have been using touch and sight together? Why?

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Name That Taste

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Objective:

This experiment is designed specifically for students in grades three to five. However, it should also be helpful for students in grades six to eight with minimal adjustments. It can accompany lessons which target the five senses, especially the senses of taste and smell or it will work well as a singular experiment which will enhance basic observation skills. Students will learn how the different taste sensations are experienced, particularly that sweet and sour sensors are located on specific parts of the tongue.

Materials Needed:

- Q-tips
- Lemon juice
- Vinegar
- Paper towels
- Granulated sugar
- Shock tarts (candy)
- Cups (4 per group)
- Blindfolds
- Tongue map (This is the shape of the tongue. Show students a design of the of the tongue with the specific taste areas labeled. Have them to create their own map from this design without labeling.)

This experiment should be conducted by students in groups of two or more. This will allow students to act as the subject, experimenter, recorder and observer. Students will need three maps each.

Strategy:

Place the lemon juice, vinegar, sugar and shock tarts in separate cups. Label the bottom of each cup to indicate the contents. On the sides of the cups, write A, B, C or D and place on a table facing the recorder. The subject (or taster) should be blindfolded. Using a clean Q-tip each time, the experimenter will dip the end into one of the cups with the liquid content and place on different areas of the student's tongue. The shock tarts should be placed in the subject's hand and they will place it on different areas of their tongue. Each time the tongue is touched, the student should be asked to identify the taste sensation that they experienced. Each response should be noted by the recorder on the tongue map. Once all students within the group have completed the task, allow students to conduct the experiment again. This time the blindfold should not be included. The experiment should be conducted a third time. This time students will hold their nose and complete each step of the experiment. When the experiment is completed, students should review their individual responses and then compare them with the other students in their group. each group will write their overall results and compare with the rest of the class.

Performance Assessment:

Students will now be able to complete tongue mapping by labeling the areas of the tongue that are more sensitive to a specific taste and areas where taste sensations may overlap with each other. They will also understand how the sense of taste is influenced by both sight and smell.

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Breathing Is Essential to Life

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Objectives:

Students in the primary and intermediate grades will: 1. Recognize that breathing is a necessary, automatic life process; 2. Observe and record data on respiration rate; 3. Demonstrate how air enters and leaves the lungs; 4. Observe how respiratory rate changes with different activities; 5. Use counting as a means of gathering data

ACTIVITY #1: COLLECT ONE OF THE GASES IN YOUR BREATH

MATERIALS: paper towel
hand mirror

PROCEDURE:

Use the paper towel to clean and dry the mirror. Hold the mirror near, but not touching, your mouth. Exhale onto the mirror two or three times. Examine the surface of the mirror.

QUESTIONS: What happens to the mirror?
Why does the mirror become fogged?

ACTIVITY #2: LISTEN TO PARTNERS BREATHING; COUNT BREATHS PER MINUTE

MATERIALS: stethoscopes
watch or clock with second hand
index cards or sticky note paper with student's names

PROCEDURE:

Use a stethoscope to listen to one another's breathing. Hold breath as long as possible; record how long you held your breath. Pair off students: **Breather**: All students sit quietly (lie down if possible) with hands placed over their stomachs or chests. **WATCHERS**: The watchers must watch their partners and count the breaths taken in one minute (count ONE breath for every time the stomach or chest rises). Teacher cues the watcher when to begin and when to stop after 60 seconds. After the 60 seconds, watchers tell the breathers how many breaths were counted. Then all breathers record their at rest information on the index card or sticky note paper. Students trade places and repeat the activity. Next, students do jumping jacks or run in place for 60 seconds before recording breathing rates as described above.

QUESTIONS: In which case did you breathe more? Why?
Do you think respiration rate would be faster or slower if you ran for 10 minutes before counting breaths?
Would there be a difference in your respiration rate if you checked

it when you were sleeping and then again if you were walking?
Why can't we hold our breath for 5 minutes?

ACTIVITY #3: MEASURING LUNG CAPACITY WITH BALLOONS

MATERIALS: 6" and 9" balloons
cloth tape measure
paper and pen or pencil

PROCEDURE: **CAUTION** Do not do this activity if you have asthma!

Give identical balloons to pairs of students. Instruct each to blow up a balloon as much as possible with only one breath. Measure how big around everyone's balloon is with a tape measure and write down the numbers next to the persons names. Let air out of balloons and repeat two more times. Take an average of three tests.

QUESTIONS: Who was able to blow the most air into their balloon?
What is it about the person that enables him or her to do this?
If you ran in place for 2 - 3 minutes, would you be able to blow as much air into the balloon? Try it.

ACTIVITY #4: **CONSTRUCT A LUNG**

MATERIALS: scissors
1 or 2 liter soda bottle with label removed
7" and 9" balloons
helper

PROCEDURE:

Cut off and discard bottom of soda bottle. Invert the 7" balloon inside the bottle after stretching the balloon over the mouth of the bottle. Cut top off a 9" balloon and stretch this top over the bottom of the bottle. Hold the bottle with one hand and, with your other hand move the surface of the balloon at the bottom of the bottle by pulling and pushing it.

QUESTIONS: What happens to the balloon?
Why does it inflate and deflate?
What large muscle is important in inhaling and exhaling and how does the model demonstrate its action?

ACTIVITY 5: **MEASURING LUNG CAPACITY WITH WATER**
MATERIALS: paper and pen
large pan
empty 1 gallon plastic bottle with a cap
plastic tubing
antiseptic wipes

PROCEDURE:

Make a chart with names of participant. Label name, weight, height and code. For each person tested, fill in the information on the chart, and give a different code letter of the alphabet starting with "A". Pour about 3 inches of water into a large pan and set it in a sink or on a counter. Fill a gallon jug with water and screw on the cap. Place the jug upside down into the pan of water. Remove the top of the jug so that the water remains inside and slip a 3 foot length of clear plastic tubing into the jug. Ask each participant to take a big breath and blow as much air as they can into the length of the tubing. Mark the water level on the jug both before and after blowing and record on the chart. Wipe the tubing clean with the antiseptic wipe before another subject uses it. Compare the data you gathered from your test.

QUESTIONS: Who was able to blow the most air into the water?
What was it about the person that enabled him or her to do this?
If you ran in place for a few minutes, would you be able to blow as much air into the water?

ACTIVITY #3: **OBSERVING AN ANIMAL LUNG**

MATERIALS: an animal lung (sheep or cow)
plastic tubing
scalpel (optional for dissecting lung)

PROCEDURE: Observe trachea, bronchi, bronchioles, and alveoli of animal lung. Observe how lung inflates by blowing air down trachea with plastic tubing.

QUESTIONS: Is the lung of a sheep or a cow the same as a human lung?
What happens when you blow into the trachea with the plastic tube?

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Sound and Hearing

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Objectives:

To demonstrate that sound travels.
To explore how sound is reflected, amplified and recorded.
To investigate the physical components of the ear and the way it works.
This lesson is designed for a 5th or 6th grade class.

Materials Needed:

one cookie box or cake tin
rubber bands
uncooked rice
scissors
sauce pan or baking tray and wooden spoon
plastic wrap or balloons
cardboard tubes
1 or 2 candles
modeling clay
1 tape recorder and microphone
flashlight
index cards or pieces of smooth posterboard
alarm clock or softly ticking metronome
blindfold
a blank cassette tape
2 funnels
1 yard of flexible plastic tubing

Strategy:

Sound as waves

Activity #1: Stretch the plastic wrap or balloon over the cookie tin; secure with rubber band(s) and sprinkle a few grains of uncooked rice over the plastic. Hold the baking tray over the can. As the tray is being hit with the wooden spoon, the rice can be seen moving and jumping over the plastic membrane. This activity shows that sound travels in waves and reaches our ear drum or tympani much in the same way as it vibrates the plastic over the cookie tin.

Activity #2: Stretch a piece of plastic wrap or balloon over both ends of a cardboard tube; secure with rubber band(s). Make a little hole in the plastic at one end of the tube only. With the clay, build a short stand that has the same height as the candle. Lay the tube over the stand, with the pierced end pointed towards the candle, and just a few inches away from it. Tap the other end with your finger. The vibrations blow out the candle. This activity shows how the vibrations made by tapping the drumhead move down the cardboard tube and push the air out through the little hole at the opposite end, much like they travel down our ears. The pitch or tone of sound waves is measured in Hertz.

Waves: direction and reflection.

Activity #3: this is a game for the whole class room. The class sits down in a circle. One person volunteers to wear a blindfold and sit in the middle. The other players are quiet and a designated student makes a gentle noise, such as popping his/her fingers. The blindfolded student must point in the direction of the noise. Many different players can take a turn at being blindfolded. Whose ears have the best sense of direction?

Activity #4: Use modeling clay to secure 4 equal pieces of cardboard tube in an horizontal manner. They must form a zigzag pattern with an angle of about 90^o between each tube. Without changing that angle, place a square of posterboard facing the adjoining end of the first and second tubes, another square of posterboard facing the ends of the second and third tubes, and a third piece of posterboard facing the ends of the third and fourth tubes. Place a microphone hooked to a tape recorder at one end of this contraption. Set a ticking metronome or alarm clock at the opposite end, but away from the opening of the first tube. The tape recorder will record either nothing or a very faint sound. Now, place the metronome right at the opening of the first tube. The resulting recording should be quite clear. Different experiments can be done: change the directions of the tubes and determine which direction give off the clearest sound; or replace the smooth cardboard with reflector cards of different material or egg cartons. This activity demonstrates that sound waves in air will bounce off a flat, solid surface, like a ball bouncing off a wall. If, however, the sound waves are bounced off a surface that is soft or bumpy, the waves will break up or fade away. Volume is measured in decibels.

Amplifying and recording sound.

Activity #5: making a stethoscope. Take a piece of plastic tubing that fits tightly over the narrow ends of 2 funnels. Attach a funnel to each end. Ask a student to put one funnel over his/her chest and another student to put the other funnel, at the other end over his/her ears. He/she should be able to hear the other student's heartbeat. This activity demonstrates how some devices can amplify sound. The shape of a cone is used to amplify sounds whether receiving them (stethoscope), or sending them (megaphone).

Activity #6: Students face a microphone in a row or two, depending on their numbers. They sing a song together in the microphone, hooked to the tape recorder. The tape will pick up the voice nearest to the microphone drowning the rest. Then, the microphone is tied to the handle of an open umbrella,facing the students standing at the exact same place. Play the tape back. The voices are far clearer than on the first recording. The same experiment can be done recording birds outside. This activity shows students how the umbrella's shape collects the sound waves and reflects them back to the microphone.

Make a model that demonstrates how the ear works.

Activity #7: Stretch plastic wrap over one end of a tube and secure with a rubber band. Roll another sheet of paper to make a cone and insert the smaller end into the other end of the tube. Stand an index card in a vertical way, (secure with modeling clay) very near the end of the tube with the plastic wrap. Shine the flashlight on the plastic wrap so that the light is reflected onto the card. Then shout or sing loudly into the cone. Results: the reflected light should flicker. The cone represents the outer ear (pinnea), the tube is the ear canal and the wrap represents the ear drum (tympanic membrane). When sounds are captured by the outer ear and travel down the ear canal, the eardrum vibrates.

Performance Assessment:

Students should be able to retrace any experiments of their choice step by step. They should know how to explain the following terms: hertz, decibel, stethoscope, pitch, volume, outer ear, ear canal, ear drum, amplify, sound wave, string, wind and percussion instruments.

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Bones, Bones, and More Bones

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Objectives:

This lesson is designed for primary grade levels 2-3, although it can be adapted for intermediate and upper grade levels.

Students will be able to describe the functions of bones in the human body.
Students will be able to describe the make up of a bone.
Students will be able to recognize that hollow bones have more strength.
Students will comprehend that the depletion of calcium in bones causes them to become weak.
Students will be able to describe what the backbone is made up of.

Materials Needed:

ACTIVITY 1
Pictures of Bones
Examples of Bones
Pictures of Joints
Clay

ACTIVITY 2
Paper
Tape
Paper Plates
Measuring cups
Weights (Blocks-small)

ACTIVITY 3
4 Chicken Leg Bones
Vinegar
Containers (4jars)

ACTIVITY 4
Empty Thread Spools (assorted sizes)
String, Scissors
Tape, Balloons
Ruler, Hole Puncher

Background Information:

The skeletal system of the human body is made up of bones. These bones make up the body's shape and protect the internal delicate body parts. An adult person has about 206 bones in his/her body. The number of bones in a person's body varies from person to person. This is due to the discrepancies in the number of little bones in the hands and feet. The bones in the human body are distributed in this way: skull=29, spine=26, ribs and breastbone=25 shoulders, arms, and hands=64, pelvis, legs and feet=62. The central support system for the body is the spine. The spine is made up of 26 linked bones called vertebrae.

Strategies:

ACTIVITY 1 "BONE MAKEUP"

1) Teacher will show students a picture of a bone pointing out the various parts of the bone, and reviewing important vocabulary.
2) Students will create a clay model of the bone, labeling the parts of it.
3) Teacher will introduce the four joints of the human body.

4) The teacher will demonstrate the movements of the joints.
5) Teacher will provide examples of each joint.
6) Students will match up joints with examples.

ACTIVITY 2 "HOLLOW STRENGTH"

1) Students will roll up a sheet of paper (8 1/2 x 11) about 1 in wide into a cylinder. They will make 3 of these (paper bones).
2) Students will stand the bones up on their ends, placing a paper plate on top of the bones.
3) Teacher will ask students to tell what is happening - the hollow rolls will support the plate.
4) Students will begin to add weights (wooden blocks) to the plate.
5) Students will count how many blocks the plate can hold before it collapses the bones.
6) Students will roll 3 more sheets of paper as tightly as they can so that there is no hollow section.
7) Students will stand these "bones" up as before placing the same plate on top of them.
8) Students will place weights on top of the plate until they collapse.
9) Students will deduce what happened. Teacher will explain that hollow bones were able to support more weight. Teacher will also explain that having a hollow center gave the bones a better design and made them stronger. Teacher will continue explaining that the large bones in our body are also hollow, which makes them strong so they can support more weight, but light, so it takes less energy to move them.

ACTIVITY 3 "DEBONING"

1) In cooperative learning groups, students will observe chicken legs soaked in vinegar in jars.
2) Students will observe bones that have not been placed in vinegar.
3) Students will compare and contrast the similarities and differences of the sets of bones.
4) Students will deduce that the bones that were placed in vinegar were weaker and more flexible.
5) The teacher will explain that the vinegar contains an acid which dissolves the calcium phosphate in the bones. Without calcium bones will lose their hardness and will become weaker.

ACTIVITY 4 "GET A BACKBONE"

1) Students will get the following material: 2 large, 2 medium, and 2 small empty thread spools, 1 pencil, scissors, ruler, hole puncher, string, and tape.
2) Students will draw 5 circles on the cardboard by tracing the base of 2 large, 2 medium, and 1 small spools of thread.
3) Students will cut the circles out and will punch holes through the center of them.
4) Students will cut an 18in (45cm) length of string.
5) Students will began threading the spools of thread together beginning with the largest spools, taping the string to the bottom of the largest spool (cardboard circles of corresponding sides will be threaded between each pair of spools).
6) Students will blow up a balloon and will place it on top of the model.
7) Students will stand the column of spools on the table (largest on the bottom) and push top spools about 2 inches to the side.
8) Teacher will explain that the small spools at the top represent the cervical vertebrae, the medium spools represent the thoracic vertebrae and the larger bottom spools represent the lumbar vertebrae. The

teacher will also explain that because the vertebrae, like the spools, are not permanently attached together the human body can bend and lean in different directions. Between each pair of vertebrae is a disk of cartilage that acts as a shock absorber, just as the cardboard circle between the spools keeps them from knocking together. Without this flexible disc the vertebrae would grind together and the body would be able to twist, turn, or bend the torso without pain and damage.

Performance Assessment:

Activity 1
1) Students will color and label the parts of a bone on a ditto sheet.
2) Students will match the joints of the body with examples that represent their movements.

Activity 2
1) Students will observe both models of the bones and will record the differences.

Activity 3
1) Students will observe, and compare/contrast the bones using a Venn diagram.

Activity 4
1) After making model, students will label the three regions of the back.
2) Students will be able to explain how the spine moves.

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An Introduction to the Senses

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Objectives:

Primary students will identify body parts associated with the five senses. They will name the five senses. They will perform simple experiments involving the senses.

Materials Needed:

Several empty 35 mm film canisters, baby powder, lemon, jar of dill pickles, cinnamon, peppermint oil, chocolate, unpopped popcorn, salt, air popper, fresh dill weed, fresh mint leaves, small fabric samples of various textures, sheets of various grades of sand paper

Strategy:

Begin by making air popped popcorn for the students. Discuss all the ways in which they were able to know that popcorn was popping. Allow students to eat some popcorn and continue discussion. Divide students into groups of four or five. Distribute numbered film canisters containing lemon, dill pickle, cinnamon, peppermint, chocolate, and baby powder. Students will discriminate between the six smells and write the appropriate number next to each on a list. After students have completed the smelling activity, allow them to see what was in the six canisters. Give students the opportunity to see fresh dill weed and mint.

Distribute each film canister containing salt or popcorn kernels. Students will shake the canisters and be able to distinguish between the two sounds. A student will walk around the room shaking the canister. Students cover their eyes and point to where the sound is coming from. Students repeat the activity covering one ear at a time.

Students will be given the opportunity to taste either a piece of chocolate or a dill pickle. They will be asked to try to determine where on the tongue the taste buds are located for the tasting of sweet and sour. After students conclude that sweet is tasted on the tip of the tongue, discuss the reason why we like ice cream cones and lollipops. Students should be led to discover that sour things are tasted on the sides of the tongue toward the front.

With eyes closed or wearing blindfolds, students will be given pairs of circle shapes cut from various types of fabric and various grades of sandpaper. Students will attempt to match two like circles.

Performance Assessment:

Students will point to their body parts that are associated with each of the five senses. Students will draw a head and a hand print and label the sense of touch, taste, sight, smell, and vision on the drawing.

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Making and Using a Gel Person to Teach Human Anatomy

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Objectives:

High school students will use a gel person to:

1. describe the overall body plan of a human
2. identify the major organs of the human body
3. aid in the visualization of scanning imaging
4. describe anatomical planes and directions
5. make transverse sections

Materials Needed:

MAKING A GEL PERSON
unflavored gelatine (.25 Oz. Envelopes)
blue food coloring (optional)
gel person mold (gingerbread man)
pasta (assorted shapes & sizes, cooked)
vegetables (beans, cauliflower, cooked)
tray or plate
*materials will make two GEL Persons

VISUALIZATION OF SCANNING IMAGING
gel person
plastic or glass (4" x 6")
ring stand or bracket (optional)
flashlight or small lamp
white card (8.5" x 11")

MAKING TRANSVERSE SECTION
gel person
plastic knife
index cards (4" x 6")
pencil
ruler (15-30 cm, marked in cm)
paper towels and disposal bag

Strategy:

MAKING A GEL PERSON

1. Obtain two gelatine molds in the form of a person.
2. Mix two envelopes of unflavored gelatine into 1.25 cups of boiling water until dissolved. Add one drop of food coloring. This will give some contrast to the "organs" inside the gel person without losing too much transparency.
3. Pour enough of the warm gelatine solution into the bottom of the mold to just cover the bottom (anterior surface of the person). Place in a refrigerator until it gels (about 30 minutes). Set aside the remaining gelatine solution until Step #5.
4. Place pasta and vegetables in the mold on top of the gel.

   Use a small floret of cooked cauliflower in the head (to mimic the brain). In the rest of the body, use any or all of these:
   - several pieces of cooked small elbow macaroni (to mimic hollow organs).
   - one piece of cooked mostaccioli rigati (to mimic a large hollow organ with an irregular surface).

- 2 or 3 canned red beans (to mimic solid organs such as the kidneys).
- one short strand of cooked vermicelli (to mimic solid fiber-like organs such as nerves). You might want to coil a piece of this to show how coiled organs show up in a transverse section.

*Use other soft materials as you desire in addition to, or in place of, those listed.

*Do not use too many pieces. Spread things out a little. You can also put "organs" in the arms and legs as well as the middle part of the body.

5. Fill mold to the top with the remaining gelatine solution. Refrigerate until solid (about 30 minutes).
6. Remove mold from refrigerator and dip in hot water for a few seconds to loosen gelatine. Place a tray or plate over the mold and invert, dropping gelatine form onto tray. Use the gel person as soon as possible. Gel persons can be refrigerated but they do not freeze well.

VISUALIZATION OF SCANNING IMAGING

1. Place one gel person on a 4" x 6" plate of glass or transparent acrylic.
2. Clamp the plate (with the gel person on it) to the ring stand. Instead of using a clamp and ring stand, you can simply have a volunteer hold the plate steady.
3. Use a flashlight or lamp to cast a shadow on the white card. Do this by holding the light source above the gel person and the white card below the transparent plate. This demonstrates the principle of standard X-ray photography.
4. Holding the light source in one hand and the white card in the other, rotate the pair around the gel person without changing the distance or angle of your hands. This mimics the action of an axial scanner used in creating CT scans.
5. Discuss how a scanned image can produce a 3D image of the contents of the body or of an individual organ.

MAKING TRANSVERSE SECTIONS

1. Lay one index card in front of you so the long side is along the left and right and the short side is at the top and bottom. Use a metric ruler and pencil to mark off one index card into 1cm segments. Start at the top by making a line 1cm from the top and proceed down the card. Number each segment by writing a number along the left edge of the card with your pencil.
2. Place a gel person on the index card that you have just marked off into 1cm sections. It should just fit on the card if the lines are along transverse (horizontal) planes of the gel person's "body".
3. Using a new index card, mark off 1cm lines as you did in Step #1. Now sketch the outline of the gel person on this second card exactly matching the way it lies on the first card. Then sketch in the structures or "organs" you see inside the gel person. Keep the sketch simple but accurate.
4. Beginning at the top of the gel person's head, use a plastic knife to cut a transverse section along the first line on the underlying card. That is, cut a transverse section 1cm from the top of the head. Place this section, inferior side up on a clean index card. Mark the number of the section (#1) along the left edge of this clean card.
5. Continue to cut sections in order: at the 2cm mark, at the 3cm mark, and so on, until the gel person's body is completely sectioned. After marking each section lay it on a clean index cards. Three or four sections should fit on each card. Do not forget to mark the number of each section along the left

edge of the clean card as you lay them down.
6. Make a sketch of each section on index cards.
7. Discard your material in the disposal bag. Return usable items (unused cards, pencils, rulers) to the instructor.

Performance Assessment:

At the completion of this lesson students will accomplish the following:

1. Describe anatomical position.
2. Identify the major organs of the human body.
3. Locate and describe anatomical planes and directions.
4. Describe the relationship between your original sketch (made before you cut the gel persons into segments) and the sketches of the transverse sections.
5. Explain how this "transverse sectional anatomy" improved your understanding of how the gel person is structured.
6. Explain how this dissection relates to scanning medical images that might be made of your gel person.

Conclusion:

This activity aids students in understanding and visualizing the mechanics of scanning imaging as a diagnostic technique.

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Give Me A Hand, I'm "Thumb-body" Special

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Objectives:

This lesson is designed for students grades 4-8. The students will be able to: label the bones in the hand; create a model of the hand; compile a set of fingerprints; and realize the importance of the thumb.

Materials Needed:

Note book paper
Index cards (1 for each student)
Crayons
Flour
Water
Pencil
Scotch tape
Masking tape
Scissors
Blank paper
Wax paper

Strategy:

Activity number 1

The students will begin by discussing the most used part of the body, the hands. The students will make a short list of activities that they can do with their hands. Then they will make a list of activities that can be done without the use of the hands. All answers will be discussed.

Activity number 2

The teacher will have the students toss a ball around the classroom using their hands. The teacher will ask the students what they just did. Then they will write down how they threw the ball. The class will discuss the needed hand movements. Then the students will pass a small ball by using any part of the body other than the hands.

Activity number 3

The students will place their fingers together at the second knuckles with the pinkies up and touching. They will try to move them without sliding them sideways. The students will try this with each finger to determine which fingers are immobile.

Activity number 4

The students will tape down their thumbs and try to complete a number of exercises, such as writing, catching a ball, buttoning clothes, etc.

Activity number 5

The students will use a mixture of flour, salt, and water to create dough. They will flatten it out and press their hand into it to create a handprint. A partner will use a plastic knife to cut the excess dough from between the fingers. The students will then place the bone structure cut out in the appropriate parts of the hand. The dough will be left to dry for several days.

Activity number 6

The students will trace their hand on a blank sheet of paper. They will make fingerprints by using a pencil to make graphite shavings. Then they will rub their finger across the graphite. The partner will place a one inch piece of clear tape across the darkened part of the finger. This piece of tape will be applied to the matching finger on the traced hand. This is continued until all fingers are done.

Performance Assessment:

Students will be assessed on participation and following directions. They will also be assessed on identifying and labeling the bones in the hand.

Conclusion:

At the conclusion of this lesson the students will be able to identify the anatomy of the hand including the fingerprints. They will also know the importance of the hand and its many uses.

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Measuring Work

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Objectives:

Students will explain what work is, measure work done in moving an object, and tell how energy is related to work in both machines and the human body.

Materials Needed:

meter stick, bathroom scale, paper, pencil, and a flight of stairs

Strategy:

Part-A: How Much Work Can Your Body Do?

1. Students will walk up a flight of stairs, counting the number of stairs in the flight.
2. Students should measure (in centimeters) the height of one stair and multiply that number by the number of stairs in the flight. This will give them the distance.
3. Students weigh themselves using an ordinary bathroom scale and calculate their weight in N (Newtons). 1 lb equals 4.5 N. This will give them the force.
4. Finally, students will calculate how much work is done when they walk up a flight of stairs. Work is measured in N-meters. The formula for measuring work is, W = F x D.

Performance Assessment:

-Student correctly uses the meter stick to measure the height of one stair.
-Student correctly weighs himself using an ordinary bathroom scale.
-Student correctly calculates his weight in newtons.
-Student correctly calculates the distance in meters.
-Student correctly calculates the amount of work done in walking up a flight of stairs.

Part-B: Can Simple Machines Help Us Do Work?

Materials Needed:

construction paper (13 cm x 13 cm), straight pin, ruler, unsharpened pencil (with an eraser), 45 cm length of string, one-quart size milk carton, scissors, paper clip, a heavy object

Strategy:

1. Students build a model windmill using the 13 cm x 13 cm piece of construction paper, the straight pin, and the unsharpened pencil.
2. Students should cut the top off the milk carton. Then cut 2 deep U-shaped

groves in opposite sides of the milk carton. Put a heavy object into the carton to weigh it down.

3. Tie a paper clip to one end of a piece of string. Tape the other end of the string to the writing end of the pencil.
4. Set the windmill into the groves of the milk carton at the edge of a table so that the paper clip on the string hangs freely.
5. Students predict what will happen when air is blown across the top of the windmill so that the blades catch the moving air.
6. Students should (by mouth), lightly blow across the top of the windmill so that the blades catch the moving air.

Performance Assessment:

-Student is able to make a reasonable prediction concerning the performance of the windmill blades.
-Students can reasonably describe what happened when air was blown on the blades of the windmill.
-Student is able to conclude that moving air on the wheel and axle of the wind-mill allows the windmill to act as a simple machine.

Part-C: Our Body the Machine:

Materials Needed:

Pictures of foods, glue, scissors, construction paper, play food to represent the four food groups, chart of the four food groups, chart showing the recommended daily nutritional requirements, and a chart that shows the nutrients found in some common foods. The chart should also include examples of food sources and the body's need for each nutrient.

Strategy:

1. Students will run in place, and perform a set of jumping jacks.
2. Ask students what allows them to be able to perform these simple exercises?
3. Tell students that the energy needed to perform these simple exercises, comes from the varied foods they eat.
4. Students use a nutrition chart to examine some common foods, their nutritional value, and how the food supplies the body with energy.
5. Students give examples of "junk foods" and "healthy foods."
6. Students identify the four food groups and classify play food into the four groups.
7. Students describe a balanced diet.
8. Students create a balanced lunch using some common lunch items.
9. Students use pictures of food items to create a collage that represents a balanced breakfast, lunch, and dinner.

Performance Assessment:

-Student correctly classifies foods into the four food groups.
-Student creates a collage of food choices that reflect a balanced breakfast, lunch, and dinner.

(See the activity sheet on the next page.)

Activity Sheet: Part-A

How Much Work Can Your Body Do?

Materials: meter stick, bathroom scale, pencil, paper, and a flight of stairs

Procedure:

A. Weigh yourself in lbs. Calculate your weight in Newtons (1 lb equals 4.5 Newtons).
B. Walk up a flight of stairs. How many stairs are in the flight?
C. Measure the height of one stair.
D. Calculate the distance (The bottom of the flight to the top).
E. Calculate how much work you do in walking up the flight of stairs.

Data Sheet

1. My weight is _____ lbs

2. The force I will use is my weight in Newtons. The force is _____
   WORK SPACE _____lbs x 4.5 Newtons = _____

3. The height of one stair is _____ cm

4. The number of stairs in the flight is _____

5. The distance I will walk is _____ meters
   WORK SPACE height of one stair _____ x _____ the number of stairs in the flight

6. Walk up the entire flight of stairs

7. How much work did you do when you walked up the flight of stairs?
   _____ Newtons x _____ meters (distance) = _____ Newton-m of work

8. I can infer that a person with a __________ weight will do less work than a person with a __________ weight when walking up a flight of stairs

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Exploring the Left and Right Sides of the Brain

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Objectives:

This lesson is designed for use with 5th-8th graders. The purpose of the lesson is to have students become familiar with the left and right hemispheres of the human brain and to engage in activities that activate powers that are dominant in each hemisphere. This lesson could be used as a culminating activity after a unit on the brain.

Materials Needed:

* **Drawing on the Right Side of the Brain**, by Betty Edwards, Chapter 1-4 for teacher reference
* model of brain (if available)

For each student:

* Any logic activity (I used AIMS Logic Activity "Who's Who on the Baseball Team?" from AIMS Newsletter July/August 1993)
* Copies of an optical illusion (I used "Old Lady, Young Lady")
* Copies of Cartoon of dog, from **Your Body** kit, (Lucas Manufacturing Company) pg.35, or any line drawing that has recognizable objects (e.g., people, houses, etc.)
* drawing paper and pencils

Background Information:

During the 1960's, doctors discovered through working with patients that had severe epileptic seizures that each hemisphere of the brain processes information differently. Through a series of tests they concluded that both hemispheres use high-level cognitive modes, which although different, involve thinking, reasoning, and complex mental functioning. The left hemisphere is dominant in verbal, analytic, abstract and logical activities. The right hemisphere is dominant in nonverbal, analogic, nontemporal, intuitive, and spatial activities. (Refer to page 40 in **Drawing on the Right Side of the Brain**. Note differences in language domain in the left side and spatial domain on right side.)

Strategy:

1. Work with a partner to do "Who's Who on the Baseball Team?" Teacher should coach students to **follow directions** in a sequential manner. Model by doing the first two items with students.
2. When students are finished, go over the answers and discuss how they reached their conclusions. Lead them to understand that the logical thinking they engaged in was based on putting information in order or in sequence.
3. Teacher explains the theory of the brain's left and right hemispheres. (See Background Information.)
4. Give students directions to make a face-vase drawing:
   a) Draw a profile of a person's head on the upper left side of the paper,

having the profile face towards the center of the paper. (Left-handed students should start on the right side of paper). Try to use your own memorized symbols for a human profile.
   b) Draw horizontal lines on the top and bottom of your profile, forming the top and bottom of the vase.
   c) Go over your drawing of the first profile with your pencil, naming the features to yourself as you go, i.e., forehead, nose, upper lip, lower lip, chin, neck. Repeat this step at least once. This is a left-hemisphere task -- naming symbolic shapes.
   d) Starting at the right side of the horizontal line, (the left side for left handers) draw a second profile facing the center of the paper. The second profile should be a reversal of the first in order to be symmetrical. You may experience a sense of mental conflict at some point in the drawing of the second profile. Observe this and observe how you solve the problem.
5. Elicit discussion from the students about their experience in drawing the profile/vase. Lead them to understand that the first side of the profile was done from memory and from naming the parts. This is left-hemisphere mode. To complete the drawing, students probably had to scan back and forth in the space between the profiles, estimating angles, curves, inward-curving and outward curving shapes, which now had become unnamed parts -- shapes of space between the two profiles. This is right-hemisphere mode -- thinking without words.
6. Distribute copies of a cartoon or simple drawing. Have students first draw the picture right-side up. When they are finished, they should turn the picture upside down and draw it again as they see it (i.e., upside down). The purpose of drawing the picture upside down is to have them attempt to draw without naming objects, but rather to employ the right hemisphere's ability to analyze spatial relationships.

Performance Assessment:

When you're finished, have the students decide which of their drawings is better and which way of drawing (i.e., right side up, in which they use language to identify objects, or upside down, in which they analyze spatial relationships) enabled them to create a better drawing. Lead the discussion in terms of right and left brain hemisphere modes of thinking.

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Immunity and Disease

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Objectives:

This Mini-teach lesson is designed for 5th-8th grades. Students will learn how the immune system (an assortment of cells and tissues coordinated through a complex network of molecular messages and interacting genes), fights a war with a pathogenic organism: one of the many bacteria, viruses, and protozoans that can infect our bodies and cause disease.

Materials Needed:

Movie (**The truth about HIV and AIDS**), Construction paper, and Game Board.

Strategy:

Activity 1: The students will be shown the movie on HIV and AIDS which will give them an insight on the immune system, the way the disease is transmitted, and to see and hear other young people who have contracted the disease, and how they are dealing with it, as well as young people who don't have the disease, and what they are doing not to contract it.

Activity 2: Students will cut out letter shapes, and try to fit them into other letter spaces, i.e., trying to fit the letter X into shape O. What this activity shows is how the white blood cells in the immune system fight off any foreign invaders, and how other "X's" will come to destroy the "O" because it does not belong. Yet when the HIV virus enters the blood system, the system is broken down and any foreign invader can enter the body and destroy it.

Activity 3: After Activities 1 and 2, you should have a 30-40 min. lecture and answer and question period on the movie and other hand outs on immunity and disease. The game board is used to play "Jeopardy" answering questions about things that are familiar to students about the disease or immune system (for example, "This NBA star retired after learning be was infected with the HIV virus". Ans: "Who is Irvin "Magic" Johnson"?). This activity will be enjoyable to the students as well as thought provoking.

Performance Assessment:

The students' assessment will basically come from the game and a short quiz on the movie, lecture, and hand-outs as well as prior information learned through the game of life. The expected results would be that students learned how dangerous unprotected sex and doing drugs can be, and that no one is immune to catching AIDS. **SO PLAY SAFE OR NOT AT ALL.**

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Healthy Colon with Good Digestion and Fiber

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Objective:

This mini-teach lesson is designed for the 6th grade. Students will be introduced to the colon and the relationship it has with the body. Students will learn the process of digestion, the process of the colon, and why fiber is necessary for a healthy diet and a healthy colon.

Materials:

Activity one, Movement of Fiber:

2 long tubes, 1 cup of water, 1 empty cup, a small bag of high fiber raisin bran cereal or honey nut toasted oats. Students will work in pairs.

Activity two, Building a Colon:

1 wood stand, 6 or more flexible straws, 1 roll of masking tape. Students will work individually.

Activity three, Coloring the Colon:

Coloring sheet of the digestive system (As in **The Anatomy Coloring Book**), crayons and markers, sheet with the directions. Students will work individually.

Activity four, Making a Menu:

Menu sheet will present food listed for 5 days and to be served 3 times a day. The menu should state the calories for each food presented. Fat intake is optional. Students will work individually.

Strategies:

Activity one, Movement of Fiber:

Each pair of students will take one tube and place the cereal down the tube. Students will then use a liquid to push the cereal down the tube. The tube is the colon and the cereal is the fiber. The students will observe how fiber moves through the colon.

Activity two, Building the Colon:

Students will take the straws and join them at the ends. Students will then tape the straws and curve them into a circle, leaving the ends free. Finally, students will label their colon and intestines.

Activity three, Coloring the Colon:

Students will be presented with a coloring sheet followed by directions. Students are to read the directions and complete the assignment.

Activity four, Making a Menu:

Students will construct a menu for 15 meals (3 meals a day, for 5 days). Students will be presented with a list of foods, their calories and fiber content. They must consider in the menu a healthful daily intake of fiber. The daily calorie intake for an average-sized man is 2500 calories per day; for the average-sized woman is 2000 calories per day.

Here is a list of high fiber foods:

fiber:	calories:	fiber:	Calories:
asparagus	23	turnip greens	17
bean sprouts	13	broccoli	39 (1 spear)
green/giant	16	green/beet	20
kidney	105	collard	14
beets	27	kale	21
carrots	17	mustard	7
mixed vegetables	39	okra	25
potato	55	onions	27
soy beans	77	sweet potatoes	162
squash, zucchini	33	white potatoes	155
tomato	110	spinach	6

Background Information:

The colon is a natural breeding ground for bacteria. The purpose and function of this bacteria is to neutralize, dissipate, avoid and prevent a toxic condition from developing in the colon. However, there are two types of bacteria: the healthy, scavenging type know as **bacilli coli**; and the pathogenic or disease-producing kind. In a proper, clean, healthy environment the healthy scavenging bacteria will control the pathogenic kind. When too much fermentation and putrefaction is generated in the colon (due to neglecting to keep it as free from feces and waste as possible), the pathogenic bacteria proliferate and ailments result. Such waste, through a high fiber diet, must be expelled from the body, and for this purpose your colon is equipped with a very efficient system for elimination, but only if your body is in good working order.

Fiber:

Fiber is an effective vehicle to cleanse your colon. Fiber carries bile and fat out of the body. Without fiber, much of this fat is reabsorbed and recirculated through the body. By helping cleanse fat and debris from the digestive tract, gasses are also reduced, allowing for more optimal absorption of important nutrients. A healthy colon also helps the body better absorb oxygen which is important for memory and energy levels.

Finally, presented below is a list of some of the parts of the body that can be affected by a blocked colon:

lungs and bronchia
heart stomach
spleen
pancreas
kidneys
bladder
prostate
gall bladder
thyroid
nasal catarrh
sinus
eyes
ears
liver

Some other diseases:

Obesity, hypercholesterolemia, cardiovascular disease, hay fever, mineral deficiency, asthma, Parkinson's disease and certain cancers.

Performance Assessment:

Students will be able to satisfactorily answer the following questions:

1. What is the process of digestion?

2. What is the process of a colon?

3. What does "movement" mean in reference to digestion?

4. Name 5 ailments that can be linked to a blocked colon?

5. How many hours does it take for food to pass through the digestive system?

6. Where does digestion begin?

7. What is fiber and why is it important to the digestive system?

8. What is the body's "sewer system."

Conclusion:

Always consider healthy choices in your lifestyle.

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Ears and Hearing

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Activity A
Objective:

To show sound waves

Materials Needed:

rubber band
plastic bowl
sauce pan
piece of medium plastic
(like a throw-away plastic tablecloth)
uncooked rice
scissors
large spoon
tape

Strategy:

1. Cut the piece of plastic slightly larger than the bowl, allowing for the rubber band to hold it.
2. Stretch the plastic over the bowl, using the rubber band to hold it in place.
3. Tape the edges of the plastic firmly to the bowl.
4. Sprinkle a FEW grains of the rice on the stretched plastic.
5. Hold the saucepan near the plastic. Hit the bottom of the pan with the spoon.

Results:

As you hit the saucepan,the rice jumps up and down. The vibrations of the pan give out the sound waves. The sound waves travel through the air and make the plastic vibrate. The vibrations can be clearly seen as the rice jumps up and down.

Activity B
Objective:

To follow written directions
To make a model that demonstrates how an ear works
To name by common and scientific names, the first three areas of the hearing system

Materials Needed:

index cards
cardboard tube (from toilet tissue)
flashlight
rubber band
plastic wrap
tape
sheet of paper
modeling clay

Procedure:

1. Stretch the plastic wrap over one end of the tube. Secure with a rubber band.
2. Roll the sheet of paper to make a cone. Tape it together so that it does not unroll.
3. Push the small end of the cone into the open end of the cardboard tube.
4. Put some modeling clay on the index card so that it stands vertically. Lay the tube in front of it. Shine the flashlight on the plastic wrap so that a spot of light is reflected onto the card.
5. Shout or sing loudly into the cone intermittently.

Results:

The spot of light will shake very fast only when sound waves are captured.

The cone represents the outer ear (pinna); the tube represents the ear canal, and the plastic wrap, the eardrum (tympanic membrane). As sounds waves are captured by the outer ear, and channeled down the ear canal, the tympanic membrane vibrates.

Performance Assessment:

Both of these activities can be PASS/FAIL per Teacher observation.

Students will name 2 or 3 of the following terms, and the corresponding structures on a diagram:
- outer ear (pinna)
- ear canal
- ear drum (tympanic membrane)

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Staying Young with Vitamin E

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Objective:

This lesson is designed for a high school student. The main objective of this Mini-teach is to explain how Vitamin E inhibits the oxidation of phospholipid and glycolipid molecules in cell membranes possibly preventing the aging of cells.

Materials Needed:

1 Apple/Banana
4 petri dishes
Vitamin E capsules
water
2 ml mineral oil

Strategy:

1. Label the petri dishes -- 1 each of air, oil, Vitamin E, and water
2. Cut three slices of apple or banana for each petri dish.
3. Coat the surface of the fruit with oil, Vitamin E, and water and place in the appropriate dish. The control dish is air. Cover the petri dishes with their lids.
4. Make observations.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. Why do we age? Is oxidation involved?
2. Describe the structure of the cell membrane (The Fluid Mosaic Model).
3. What on the cell membrane enables the organism to recognize the cell as self in addition to acting as receptors for specific hormones and other chemical messengers for the cell?
4. How is aging an oxidation-reduction reaction?
5. Explain why the organism's immune system recognizes the cell as non-self and destroys the cell.
6. How is this destruction prevented?
7. How does Vitamin E prevent aging? air? water? oil?
8. Discuss several life threatening problems that Vitamin E may be involved in preventing.

Conclusion:

Students will understand that a cell ages due to the oxidation of phospholipid and glycolipid molecules in the membrane. Vitamin E may inhibit this process.

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Rubber Egg

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Objectives:

To demonstrate the semi-permeability of a cell membrane
To lay ground-work for discussion of osteoporosis

Materials Needed:

1 raw egg in its shell
1 jar with a lid
(egg must fit inside the jar)
clear vinegar
flexible tape

Procedure:

1. Measure and record the circumference around the center of the egg.
2. Record the appearance of the egg.
3. Place the egg inside the jar. **DO NOT** crack the shell.
4. Cover the egg with vinegar.
5. Close the lid.
6. Observe immediately, and then periodically for the next 72 hours.
7. Remove the egg after 72 hours and measure its circumference.
8. Compare the appearance of the egg before and after being in the vinegar.

Strategy:

The egg has a hard shell on the outside and the circumference will vary. Bubbles start forming on the surface of the egg's shell immediately and increase in number with time. After 72 hours, the shell will be gone and portions of it may be seen floating on the surface of the vinegar. The egg remains intact because of the thin see-through membrane. The size of the egg has increased.

The shell of the egg is made of calcium carbonate, commonly called limestone. When vinegar chemically reacts with the limestone, one of the products is carbon dioxide gas, those bubbles seen on the egg. The membrane around the egg does not dissolve in vinegar, but becomes more rubbery. The increased size is due to osmosis, the movement of water through a cell membrane. The water in the vinegar moves through the thin membrane into the egg because the water inside the egg has more materials dissolved in it than does the vinegar. Water will always move through a membrane in the direction where there are more dissolved materials. The contents of the egg stayed inside the membrane because the molecules were too large to pass through the tiny homes. This selectiveness of materials moving through the membrane is called semi-permeability.

Performance Assessment:

This is a pass/fail activity.

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Learning the Bones and Muscles of the Head and Face

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Objectives:

To create an awareness of the complexity of the human body.
To cultivate a life-long interest in the student's personal anatomy.
To learn the most important bones and muscles of the head and face.

Materials Needed:

No materials necessary. The student will be using their own cranium for the activity. An anatomy wall chart or dummy will be useful but not essential.

Procedure:

Start with the only movable bone of the skull-the mandible. Ask students to trace the outline. The mandible possesses a complement of teeth. These are of four types. Students will be able to feel or see the dentition of a partner.

The four types of teeth are incisors, canines, premolars, and molars.
The maxillary bone lies just above the mandible. It carries the upper dentition which mirrors the lower jaw.

The nasal bone is next for examination. It protects only half of the nose.
The frontal bone corresponds to the forehead. This bone and the others we will discuss for the top portion of the brain serve to cushion and protect that important organ.

Students should touch the top part of their skulls. This is the parietal bone. It is separated from the frontal by a suture which fuses together with other skull bones after we are born.

The next area of study is the occipital lobe. It is in the back of the head. The student can feel a bump there. Students should know that the area of the brain protected by this bone deals with our ability to see.

Along the sides of the skull the students can find the temporal bone. This leads them to a bump just above their jaw which is formed by a bridge of bone called the zygomatic arch. This outcropping of bone serves an important purpose as an attachment for strong chewing muscles which we will discuss next.

The above completes the examination of the bones of the skull. We turn now to the muscles and in particular those attached to the zygomatic bone discussed above. These are the temporalis and masseter muscles. Students should chew on something (a grape is good for this) and feel the muscles contract as they chew. The muscles which allow us to use our faces expressively are discussed now.

The muscle that surrounds the eye is called the orbicularis oculi. Each student should wink and feel the muscle contract.

Another ring of muscles that we use constantly is the orbicularis ori. This circles the mouth and allows us to shape words, eat, express emotions etc. One emotion that we can express with our mouths is laughter. We can pull back our orbicularis ori using a muscle attached to that muscle and the zygomatic arch. This is called the zygomaticus. Students can feel that muscle by indulging in a little risibility.
Do you know a good joke?

Follow Up:

As mentioned in my previous activity students learn what they use. After this activity the teacher should use every opportunity to reinforce the lesson. Quizzes may be given in which actions are listed. The students are then asked to name the muscle or bone that allows that action to happen.

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Straight from the Heart

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Objectives:

(These objectives are adaptable for all grade levels.)

The main objectives of this mini-teach are to define and demonstrate the functions of the heart; observe the vibration of a match due to the pulsation of blood in the wrist; to construct a simple stethoscope and use it to listen to your heartbeat; to measure your heart rate (pulse); to compare your heart rate with your partner's heart rate; and to calculate the number of times your heart beats in one hour.

Materials Needed:

Heart Model	**Vibration Observation**	**Stethoscope Models**
one-half pear	modeling clay	surgical tubing
per student	paper match	2 funnels per model
surgical tubing		modeling clay
plastic spoons		
scalpels		
"heart" vocabulary		

Strategy:

Heart Model

1. Have students turn pear upside down and remove seeds.
2. Cut out two hollow openings at the top and two larger ones directly under them to represent the four chambers in the heart.
3. Introduce the largest artery and the largest vein by inserting surgical tubing in proper positions.
4. Discuss function(s).

Vibration Observation

1. Insert the match into a very small piece of clay (the smaller the better).
2. Flatten the bottom of the clay.
3. Place your wrist, palm side up, on a table.
4. Place the clay on your wrist, and move the clay around on the thumb side of the wrist until the match starts to slowly vibrate back and forth.
5. Count the number of vibrations that the match makes in one minute.

Stethoscope Models

1. Have students work in pairs.
2. Cut the hoses for the stethoscopes into approximately 3 feet lengths.
3. Set out all the material on supply table.
4. Prepare a sample stethoscope. Slide the hose over the end of each funnel. Use clay to hold funnel in place.
5. Instruct students to be quiet because it will be very hard to hear the sound of a heartbeat if there is a lot of background noise and talking.

6. Have one student place one end of the funnel on his ear while the second student places the other funnel near the left side of the chest.
7. Have students listen to the heartbeats of themselves and partners using stethoscopes and compare rates.
8. Calculate the number of times your heart beats in one hour.

Performance Assessment:

At the conclusion of the mini-teach, students will be able to answer the following questions:

Heart Model:

1. How many chambers are in the heart?
2. What are the names of the chambers?
3. What are the functions of the chambers?
4. What is the name of the protective covering of the heart?
5. What is the name of the largest artery?
6. What is the name of the largest vein?

Vibration Observation:

How many times does the match vibrates back and forth with a regular heartbeat?
(For adults it will vibrate 60 to 80 times in one minute.
The vibration for children is from 80 to 140 beats per minute.)

Stethoscope:

1. Did you hear the "lubdub" sounds of the valves snapping shut with each heartbeat?
2. How do you think the stethoscope works?

Conclusions:

Students will understand the functions of the heart and that as the heart contracts, blood is forced through the blood vessels. The blood moves at a rhythmic rate causing the blood vessels in the wrist to pulsate. All blood vessels have this throbbing motion, but the vessels in the wrist are close to the surface of the skin and can be felt more easily. The movement of the blood under the clay causes it and the match to vibrate.

The students will also understand through the use of the stethoscope that sound waves pass along the tube to the ear and that the funnel collects the sound made by the beating heart.

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Respiratory System

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Objectives:

This lesson was designed for grades 4-6 to show that the general functions of the respiratory system are to deliver oxygen to the tissues, the importance of cellular respiration, the processes of inhalation/exhalation, determine the volume of air exhaled and to eliminate carbon dioxide formed in the body.

Students will:
- -Demonstrate that there is oxygen in the air we breathe.
- -Build a model of the respiratory system.
- -Measure the amount of air that can be forced out of the lungs.
- -Demonstrate that carbon dioxide is exhaled from the body.

Materials Needed:

Part A
1. Candle
2. Matches
3. Pan
4. Clear cup or glass
5. Water

Part B
1. 2-pieces of straw
2. 2-small balloons
3. rubber cement
4. 1-large balloon
5. rubber bands - 2 small, 1 large
6. tape

Part C
1. Lime powder
2. Water
3. Clear cup or glass
4. Straw

Part D
1. Plastic dish pan
2. 2 feet (61 cm) of aquarium tubing
3. 1 gallon (4 liters) plastic milk jug w/cap
4. masking tape
5. pen
6. an 8 oz cup

Strategy:

Part A
This experiment will show that there is oxygen in the air we breathe.
1. Place a small amount of water in the bottom of the pan, enough to cover the bottom of the pan.
2. Light the candle and place in the water on the bottom of the pan.
3. Cover the lit candle with the glass and observe what happens to the water.

Part B
This model will show the action of the diaphragm in human respiration.
1. Take a piece of straw about 2 inches in length and cut a small triangle in the center, but don't go through to the opposite side. Fit one small balloon over each end of the straw and secure it with a small

rubber band. (Make sure that air will go into each balloon when blown from the top.)

2. Bend the straw in the middle of the hole.
3. Take a second piece of straw and cut a V-shape on the end. Fit the slanted points of the straw into each semi-circle of the hole of the bent straw.
4. Cement the two pieces of the straw together. Allow to dry or use tape to hold until dry.
5. Cut a hole in the bottom of the clear plastic cup using the diameter of the straw as a guide to the size. Push the open end of the straw into the hole of the plastic cup from the inside. Cement the straw into the hole.
6. Take the large balloon and cut the neck off. Carefully stretch the cut balloon over the opening of the cup. Do not crack the cup. Secure the edges with the large rubber band. Do not cement the sides of the cup. The model will only work if there are no leaks.
7. Then pull the bottom balloon gently and observe what happens to the small balloons.

Part C

This experiment will show that carbon dioxide is one of the major cellular metabolic waste products.

1. Place about a teaspoon of lime powder in a cup or glass of warm water and mix thoroughly. Cover the glass and let remain over night.
2. Next day drain the clear fluid off the top of the solution. This is the lime water for the experiment.
3. Place the straw in the lime water and blow into the straw. Observe what happens to the clear fluid.

Part D

This experiment will demonstrate lung capacity by measuring the amount of air that can be forced out of the lungs.

1. Place a strip of masking tape down the side of the milk jug from the top to the bottom.
2. Fill the jug with water using a cup to measure amount of water it takes to fill the jug. Mark each cup on on the tape (these measurements will serve to show the amount of water exhaled) and screw on the cap.
3. Fill the dish pan about 1/2 full with water.
4. Place the jug upside down in the water, and remove the cap.
5. Have a helper hold the jug. DO NOT allow air bubbles to enter the milk jug.
6. Place one end of the aquarium tubing inside the mouth of the jug.
7. Take a normal breath and exhale through the tubing. Mark the water level on the tape.
8. Refill the jug with water and return it to the dish pan.
9. Breath in deeply and make an effort to exhale all of the air in your lungs through the tubing. Mark the water level on the tape.

Performance Assessment:

Students will be able to answer the following questions:

1. What are the chief functions of the respiratory system?
2. Why do we need to breathe?

3. What's in the air we breathe?
4. How do you know there is oxygen in the air we breathe?
5. What would happen if your oxygen ran out?
6. What do the small balloons represent?
7. What do the two ends of the straw to which the balloons are attached represent?
8. What does the longer piece of straw represent?
9. What do the sides of the cup represent?
10. What does the balloon sheet over the cup's opening represent?
11. What happened to the small balloons when you pulled down on the balloon sheet?
12. What happened to the small balloons when you push up on the balloon sheet?
13. What happens to the air once it's in the lungs?
14. What is cellular metabolic activity?
15. What is the primary gaseous waste product of cellular metabolic activity?
16. What's the stuff that comes out when you exhale?
17. What is lung capacity?
18. What happens in the plastic bottle as you exhale into the rubber tubing?
19. What effect does exercise have on the volume of air? Explain.

Conclusion:

At the end of this lesson students will understand the basic anatomy and physiology of the respiratory system.

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Mechanism of Vision

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Objectives:

This lesson is designed for junior high school students. The objectives are: learning the way light reflected from objects enters the eye; learning the basic anatomy and physiology of the eye; and learning the basic mechanism of perception.

Materials Needed:

For 5 groups of students (4-5 in each group)

The Device

10 cans of equal size (soup, tomato paste, etc.) with the lids on both ends cut out
5 holepunchers
5 toothpicks
15 rubberbands OR tape for each group
large (18"x24") black arrow
aluminum foil
wax paper

Perception Tools

5 sets of the following postcards:
--1 classic European painting, painted between 1500 and 1800
--1 photograph, preferably 20th century
--1 "primitive," American folkart or European painting before 1400
5-8 optical illusions (not the Magic Eye)

Strategy:

1. Have each group cut 2 generously-sized squares of aluminum foil and one generously-sized square of wax paper. The square should fit over the ends of the cans.
2. In one aluminum foil square, use the hole puncher to punch a hole in the center of the square (square A). In the other aluminum foil square, use the toothpick to punch a very small hole in the center of the square (square C). Do nothing to the wax paper.
3. Secure each square to the can with tape or rubber band.
4. Cover one end of a can with square A. Do nothing to the other end of that can. Cover one end of the other can with square B and the opposite end with square C. See diagram below.

```
`ffffffffffffffffffffffp           `ffffffffffffffffffffffp
w                     w            w                     w
w                     w            w                     w
w                     w            w                     w
affffffffffffffffffffffq           affffffffffffffffffffffq
|                    |             |                    |
```

square C square B nothing square A

5. Before you begin the next phase, be sure to have the arrow taped in an upright position to a very bright window. Hold the device in the manner illustrated above, with square B touching the open end of the first can. Look at the arrow. Ask the following questions:

a. What do you see?
b. How did you have to arrange the device in order to get the best image?
c. Why does the image look that way?

Explanation: light is reflected from an object and enters the lens of the eye, where it is refracted and travels to a group of light-sensitive cells in the back of the eye called the retina. Light entering at the top of the lens is refracted to the bottom of the retina; light entering the bottom of the lens is refracted to the top of the retina; light entering the center of the lens is refracted to the center of the retina. Under normal conditions, light reflected from an object is projected onto the back of the retina so that the object projected is upside down and switched from left to right. We don't perceive objects in this manner; the visual cortex "corrects" this so we see the object in its correct orientation. The device strains the light coming to the lens at the top and bottom, so that your perception of the object is fooled into seeing it upside down.

Next...

1. To use the perception tools, have each student study the three pictures. (Note: you must use the pictures described in the materials section. European paintings before 1400, as well as "primitive" art, do not have depth of perception. You also must be careful with Impressionist art because it has a tendency to be very "flat.") Ask the following questions:

a. What is the subject of the painting?
b. List some objects in the foreground and background.
c. In what ways can you differentiate between the objects in the foreground and the background?
d. How did the artist conceptualize foreground and background objects?
e. Do all three pictures have depth?
f. Draw a three-dimensional picture using the techniques you've observed.

2. To use the optical illusions, tape each one on the blackboard or around the room. Have each student look at the illusion for only 30 seconds or so. Ask them to quickly write down what they've seen. It's important that students do not talk or discuss their answers until everyone has looked at the pictures. Discuss the answers with your class. Ask them what lines or contours caused them to see the drawing as they did.

Explanation: light is reflected from objects, projected onto the retina and perceived in the visual cortex. Light is projected onto the retina as a two dimensional representation of three dimensional space. Depth perception takes place because our eyes are not in the same position and we perceive depth by the space between the different objects as they are projected onto the retina. Part of depth perception concerns our experience with the world. We touch objects as infants and can determine if the object is near or far. These experiences are imbedded in our visual cortex and we rely on them when we perceive the depth and distance of new objects. When an artist represents three dimensional space in two dimensions, she uses the same references that our brains use such as the size of an object (the further away, the smaller it is); the clarity of an object (the further away, the less distinct it is); lines of depth (straight lines going from near objects to far objects). Furthermore, contours of objects are perceived in the visual cortex. Cells in the cortex are more stimulated by changes in contours than by flat, continuous space.

Performance Assessment:

Each phase of the demonstration should be accompanied by a written lab report. Students will write their answers on this sheet. For an excellent grade concerning the device, students should: assemble the device in the manner illustrated; view the arrow upside down; explain that light is constricted by the device and causes the image to appear upside down. In assessing the appropriateness of the device, the instructor should observe that the holes are punched in the correct places, all squares are securely fastened to the cans, the device held in the correct manner, the device used to see the arrow in the correct manner. Concerning the three pictures, students should: accurately list foreground and background objects and explain that near objects are larger and more distinct than distant objects. Concerning the optical illusions students should explain why they saw the illusion in a certain way and explain that contours are very important to perception.

Conclusions:

Vision is an interplay between light reflected from the object and the mode of perception in the brain.

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Movement Across the Membrane (Diffusion)

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Objectives:

This lesson is designed for a high school student. The main objectives of this Mini-teach are to explain the concept of diffusion and to show the process how all materials enter and leave the cell.

Materials Needed:

- food coloring
- beakers
- sugar cube
- phenolphthalein
- rubber band
- raisins
- paper towel
- starch
- paper clips
- water
- air freshener/perfume
- test tube
- cellophane
- ammonia
- toothpick
- dialysis tubing/cellophane baggie
- iodine
- paper cups

Strategy:

DIFFUSION

Activity #1

1. Place one drop of food coloring into a beaker of water.
2. Observe what happens for 2-3 minutes.

Activity #2

1. Spray perfume/air freshener at the back of the room.
2. Observe what happens for 2-3 minutes.

Activity #3

1. Fill a cup with water. Gently touch the surface of the cup of water. Taste the water.
2. Drop a sugar cube in the water.
3. Taste the water every 15 seconds.

MOVEMENT ACROSS THE MEMBRANE

Activity #1

1. Fill a test tube 1/2 full with water.
2. Add 2-3 drops of phenolphthalein to the water.
3. Wrap a piece of cellophane over the mouth of the test tube. Secure it with a rubber band.
4. Turn the test tube over an open bottle of ammonia.

Activity #2

1. Obtain a soaked raisin and an unsoaked raisin. Carefully blot the raisins dry. Do not break the skins.

2. Use a toothpick to poke a hole in one end of each raisin.
3. Gently squeeze both raisins.

Activity #3

1. Obtain a piece of tubing (a cellophane baggie could be substituted). Tie a knot at one end then fill it 1/4 with water.
2. Make sure the tube does not leak. Empty the water out of the tubing.
3. Add 3 teaspoons of starch to the tubing.
4. Squeeze the air out of the tubing. Tie a knot at the open end.
5. Wash off the tubing.
6. Fill a beaker 3/4 full with water. Add 10 to 15 drops of iodine and stir.
7. Tie a paper clip around each knot in the tube. Hang the tube in the beaker of water.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. Describe what happened to the drop of food coloring/air freshener molecules?
2. How do molecules move?
3. What is diffusion?
4. What happened to the taste of the water?
5. What caused the taste of the water to change?
6. What happened to the liquid in the test tube?
7. Where was there a high/low concentration of ammonia.
8. Which way did the ammonia move? (Use the word "concentration" in your answer)
9. Explain how gases are exchanged between the respiratory system and the circulatory system.
10. How do gases pass out of the lungs into the capillaries?
11. How do the soaked and unsoaked raisins differ?
12. What do you think is coming out of the raisin, how did this liquid get into the raisin?
13. What does the skin of the raisin represent?
14. What happened to the starch?
15. What happened to the iodine and water?
16. Explain the movement of materials across the tubing.
17. Explain how foods are exchanged between the digestive system and the circulatory system.
18. How is the tubing like a membrane?
19. How does digested food pass out of the intestine into the capillaries?
20. How do materials enter and leave the cells?

Conclusion:

Students will understand the process of diffusion and its role in moving materials across the membrane.

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Cervical Vertebrae

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Objectives:

This lesson has been designed for 8th grade learners, but can be used for other levels. This lesson was developed to show through the use of diagrams and models the function of the cervical vertebrae and how easy it is to damage the cervical vertebrae. Focus: Christoper Reeve

Learners will: determine how and why he was hurt.
why he needed his breathing supplemented.
explain why he could not breath.
demonstrate how he fell.
discuss if he is a paraplegic & recovery techniques.
create their own models.

Materials Needed:

rice cakes	=	bones
marshmallows	=	discs
straws	=	spine
thread (or twine)	=	nerves
needles	=	used to thread the nerves

Procedure:

1. To soften the rice cakes for piercing by the straw, learners must drop several drops of water in the CENTER of the rice cakes.
2. When the rice cakes are soften IN THE CENTER, assemble by putting the straw through rice cake, marshmallow, rice cake, marshmallow, etc. until the desired number are lined up.
3. Thread needle with black or red thread, and "stitch" through marshmallow near the upper rice cake with a single thread. Do this for each marshmallow.

Strategy:

To simulate Christopher Reeve's accident, learners will collapse the "vertebrae" by bringing hands together with force, keeping the "spine" between middle and ring fingers, close to the palms.

Performance Assessment:

The outcome for each learner will determine how well they listened, worked in cooperative learning groups, followed directions and therefore, successfully completed the objectives. Each learner will read informational packet for discussion, participate in discussion (20%), produce one page report (50%), and construct their own cervical vertebrae section or sections (30%).

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"Da" I's Have It: A Fun Look At The Eye

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Objective:

Kindergarten level: Recognition of parts of the eye.

Materials Needed:

- sponges
- styrofoam balls
- index cards
- pencils
- string
- paper plates
- oranges
- saran wrap
- colored ribbons
- cardboard
- markers
- doll plastic eyes
- construction paper
- balloons
- paper towels
- round candies
- olives
- Pringle potato chip cans
- metallic (shiny) Paper
- "Find Waldo" Book

Strategy:

Students will construct three forms of the eye. Using a styrofoam ball, students will add a plastic eye ball by adhesion. Use a good glue to cause permanent bonding. Students will do likewise with the sponge ball. If the sponge is not shaped in the form of a ball, shape sponge into ball shape before adding plastic eye. Give time for glue to set. This is the time to construct 'fun' eye. Peel orange, keeping the orange whole, don't section it off. Stick your finger into the open groove at the end of the orange. Your finger will allow enough space for you to insert an olive. Voila! The orange is the sclera. The green of the olive is the iris, and the red represents the pupil. Point out that we see the sclera as pure white, while inside, there is a network of movement occurring, hence, the orange with its veins and grooves remind us of how the inside would appear if we could see it.

Blow balloons up and using marker, draw iris and pupil on the front of the balloon. Students can feel the roundness of the balloon and see placement of iris and pupil in relationship to sclera.

Take doughnut-shaped candies and insert a gumdrop into the center. On the center of the gumdrop, place a raisin. You now have the eye parts in an edible puzzle form.

Make tubes out of the yellow and grey construction paper. Roll one tube longer than the other. Tape the ends. Ask children to bring rods and cones up as you hold both tubes in your hands. Place rods and cones on floor in a triangular form. Have students retrieve styrofoam balls and bring them up front. Students will take turns knocking down rods and cones. The winner is the one that "bowls" the most rods and cones down.

Bring balloons and form teams on either side of makeshift net (notebook paper with holes taped to a piece of string held by two students at each end). Students will volley balloons at the same time with the winners being those who keep the balloons on their side off the floor. Instructor periodically calls the name of eye parts, for instance, "here comes the red sclera"; "I see the green sclera with the blue iris"; "Hit that black pupil of the eye dead center."

Using paper plates, black beans and glue, students will construct the first letter of their name. Instruct students to put on their blindfolds (paper towels) before beginning this project. This activity vividly portrays the importance of the eye and allows the student to appreciate the ability to see.

Using the construction paper rod or cone that students made, instruct students to hold rod or cone to side of left hand. Hold at arm's length, with both eyes open, students will be able to see a hole in left hand.

Instruct students to touch the tips of their longest fingers on each hand. Hold hands at arm's length directly in front of your eyes. Hot Dog! We have lunch. Students should be able to see the illusion of a suspended finger (hot dog) in the middle of fingertips.

Extend forefinger about 6 cm from eyes in front of you. Slowly bring finger close to your eyes, with both eyes open. You will see the illusion of two out of the one finger extended. Yea, V for victory, we've come this far.

More Eye Puzzles To Amaze and Entertain Young Ones as well as pique their interest:

Give each student a square piece of cardboard, "3 by 3" perhaps, and have them punch a hole on each side. Holes should be at the edge of cardboard and near the center, or midway through cardboard. Attach a string to each hole. Using a marker, draw a cage on one side and draw a bird on other side. Teacher can draw pictures on chalkboard as students copy. Have students hold both ends of string in hands and twirl. The bird now appears to be inside the cage. To make trick really come alive, use different colored markers, and draw your bird smaller than your cage.

Give students a lined index card. Have them color or trace lines using a marker and/or crayons. Punch hole in center of card with your pencil. Leave pencil in the hole and spin the card. Straight lines now appear to be round lines. If you put a dot between one of your lines you will get the illusion of a race track.

Give each student a Pringle potato chip can. Have them cut off the bottom end of can. They will need a plastic top and a square piece of Saran Wrap. Set aside. Pass out different colored pieces of ribbons and instruct students to cut them into small pieces. Place cut up ribbons in the plastic top. Place Saran Wrap on top of ribbons. Give each student a metallic sheet of paper which they roll to fit into their cans. Glue middle seam of metallic paper, and glue the paper to inside of the cans. Attach plastic top to can. Students turn can. They have just made their own, economical kaleidoscope. And, cheaper yet, is to place a boldly printed picture inside plastic cap. Same effect. Use Sunday funnies or magazines. No expenditure for ribbons needed.

To further reinforce retention of eye parts

"Da" I's Have It

Where: Iowa
Why: No idea
By: Ida give a hoot

Characters: Sclera, Cornea, Iris, Pupil, Retina

Sclera: (boasting) I'm TOUGH, I PROTECT ALL OF YOU, SO DON'T GIVE ME A HARD WAY TO GO.
Fultz: There goes that guy again. I haven't seen him since I don't know when. He promised me he wouldn't complain. I think he's fine, I'm glad he's mine. (You really give singing a bad name).
Cornea: You don't have to toot your horn (convincingly). We know how important you are to us. My membrane is so thin, I'm glad you provide protection yet allow light to pass through my conjunctiva, which is also transparent and produces fluid, and helps keep the front of my eye clean and moist.
Iris: Oh brother, talk, talk, talk (agitated). Tell me, can you change colors as I can, huh, huh?
Retina: (Strutting peacock) All of you step back. I'M THE MOST ASTONISHING PART OF THE BODY. AS SMALL AS I AM (postage stamp size), I CAN DETECT A DETAILED, CONTINUOUS AND MOVING VIEW OF THE WORLD IN COLOR. I'M YOUR SWITCHBOARD. I CONVERT LIGHT RAYS INTO ELECTRICAL MESSAGES AND SEND THEM TO THE WRINKLED GUY (your brain).
Pupil: (whispering) Real truth is, he gossips.
Cornea: (joining the whispering) I think Retina is part of a gang. He hangs out with the rods, the cones, who are related to a network of nerve cells called bipolar cells, and.......
Iris: (interrupting) Yes, I heard they all are connected to another layer of cells called ganglion cells.
Pupil: (Naively) Well, they ARE interconnected, and work together, so I imagine it MUST be a 'good' gang.
Iris: (indignant) What's a good gang? They wouldn't be in 'cells' if they were good. Convicts live in cells.
Sclera: I didn't mean to start a war of words, and/or wonders.
Fultz: I'm grieving, so I'm leaving, because "Eye, Eye, I've" got the blues right now. (Child, you sure give me the blues with that off key singing.) Ouch! My ears hurt.
Pupil: (sarcastically) You might think about going on a diet, you are carrying a lot of muscles, membranes, nerve endings, etc.
Iris: (coyly) I don't diet, however, I do change shape, after a meal of light, bright and/or dim.
Pupil: (mimicking) I always maintain my round shape, thanks to your help, your strong muscles, lengthening and shortening, to change my size, so that I can control light coming in.
Cornea: (bored) Do me a favor. Just keep everything out of my way and I'll remain healthy.
Sclera: (sincerely) I'm glad we had this chat, we learned much about this and that. One thing I know, the eye puts on a mighty show.
ALL; (tune of Old MacDonald) With a blink, blink here, and a tear duct there, here a blink, there a wink, everywhere a blink, blink, blink. Oh my eyes have a job, and they do it well.
Fultz: Opening mouth.....

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ALL:      (shouting)  DON'T EVEN TRY IT!
Fade to reality.........................
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Learning the Dissecting Planes

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Objectives:

This paper is designed for junior high students.
Students will learn the basic vocabulary used in dissection.
Students will learn how to orient themselves on a three dimensional figure.
Students will develop the manual dexterity necessary to use scalpels in class.

Materials Needed:

Cucumber
Scalpels
Human anatomy wall chart

Procedure:

It will be necessary to turn the cucumber into an animal. This can be done easily by cutting out holes on the anterior part of the cucumber to symbolize eyes The cucumber is now a "frog". The presence of the eyes now gives the frog an up & down position. These are referred to as the dorsal & ventral side of the animal. The location of the eyes also gives the organism a front & back. These are referred to as anterior & posterior. It should be noted at this point that the cucumber/frog can be made more lifelike by placing short straws where legs would normally be located. At this point students will be ready to begin using their scalpels. With scalpels in hand the students will be directed to make a shallow cut starting from the anterior end along the ventral side of the frog. For those students too young to use a cutting instrument it may be replaced with a Magic Marker. By the end of this part of the exercise the students should have made a shallow incision from the anterior to the posterior end of the frog. This cut is known as the sagittal incision. Now they will be instructed to cut midway on the ventral side of the organism from their left to right side. This is known as the transverse incision. The human anatomy wall chart can be used to quiz the students about their knowledge of the dissecting terminology. For this exercise the terms distal & proximate should be introduced. The teacher can then ask the students to locate a certain organ by giving them clues using the vocabulary they just learned.

Follow Up:

These terms are important to the study of life sciences & should be reviewed. The teacher might consider all situations in a normal classroom context that would require directions. These terms should be used in these situations. For example students should refer these terms to their own persons while they are in the class. Students have ventral and dorsal sides in addition to anterior and posterior directions. Objects in relation to the student's person might be termed as distal or proximate to them. The guiding principle for the retention of a scientific vocabulary is, as in any language, it's constant use.

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Some Activities For Teaching the Mechanics of Vision

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Objectives:

Students are to learn the relationship of light to vision, how light moves, how that affects what we see and some structural aspects of the eye.

Materials Needed:

Small bowl, coin, and water
3 by 5 cards
soup cans with ends removed, aluminum foil, wax paper

Strategy:

The following three activities will provide a good introduction to the process of sight:

Take the small bowl and place the coin in its bottom. Place it in front of a student at a distance that first renders the coin invisible to the student. Pour water into the bowl and the student will be able to see the coin that was invisible before.

Each student should have a 3 by 5 card held lengthways and inscribed on one end with an X in the left corner and a dot in the right corner. Students are to hold the card at arm's length, closing the left eye and staring at the X with the right eye. Instructed to draw the card closer to their face the students will notice something interesting about the image on the right. Change eyes and the phenomenon occurs on the left.

Each student should have two soup cans as described. One can to have one end covered with aluminum foil held in place with a rubber band. The other can to have one end covered with wax paper. Using a pencil point make a small hole in the center of the aluminum foil then, holding the aluminum foil can outermost with the wax paper can directly behind it (wax paper facing into the other can), place the cans in front of your eye and you will see an image appear on the wax paper.

Performance Assessment:

In the first activity explain that light travels in a straight line unless interrupted by a material with a different molecular structure. Given this, can the students explain why the coin seems to mysteriously appear?

The students must be able to describe the phenomenon and then come up with a theory to explain it based on their knowledge of ocular anatomy. A little discussion beforehand wouldn't hurt.

For the third activity the students must be able to describe the phenomenon accurately and draw a diagram to explain it.

Conclusions:

It should be stressed to the students that none of these experiments in any way changed the physical world. The phenomena that we observed occurred only within our brains. The coin did not move, images didn't really disappear or appear nor did an object invert itself. We perceived these things to happen because of the nature of our eyes and the way we interpret the information that comes to us from them.

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Inhalation and Exhalation

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Objectives:

The main objectives of this Mini-teach are to make a model of the respiratory system that will demonstrate the processes of inhalation/exhalation and to determine the volume of air exhaled.

Materials Needed:

MODEL CONSTRUCTION	VOLUME OF EXHALED AIR
2 pieces of plastic straw	food coloring
2 small balloons	water
rubber cement	paper towel
clear plastic cup	2-L plastic bottle
large balloon	2-hole rubber stopper
rubber band	rubber tubing
tape	glass tubing
	graduated cylinder

Strategy:

Model Construction

1. Take a piece of straw and cut a hole in the middle, do not go through to the opposite side. Fit a small balloon over each end. If the balloons are slightly larger than the straw, cement them to the ends. Put this aside to dry.
2. When the cement has dried, bend the straw in the middle of the hole.
3. Take a second piece of the straw and cut a V-shape at the end. Fit the slanted points of the straw into each semi-circle of the bent straw.
4. Cement the two pieces of straw together. Allow the cement to dry.
5. Cut a hole in the bottom of the clear plastic cup using the diameter of straw as a guide. Push the open end of the straw into the hole of the plastic cup from the inside. Cement the straw in the hole.
6. Take the large balloon and cut the neck off. Carefully stretch the cut balloon sheet over the opening of the cup. Do not crack the cup. Secure the balloon sheet with a rubber band. If necessary, you may tape the edges, but do not cement them to the sides of the cup. The model will work only if there are no leaks.
7. Pull down on the balloon sheet. Observe what happens to the small balloons.
8. Push up on the balloon sheet. Observe what happens to the small balloons.

Measuring the Volume of Exhaled Air

1. Fill a plastic bottle four-fifths full of water. Add several drops of food coloring to the water.
2. Put a short glass tube (does not reach the water) and a long glass tube (almost reaches the bottom of the bottle) through the 2-hole rubber stopper.

3. Connect the rubber tubing. To the short glass tube connect a piece to blow into. To the long glass tube connect a piece that will touch the bottom of a graduated cylinder.
4. Cover the opening of the shorter length of rubber tubing with a paper towel, and after inhaling normally, exhale normally into the rubber tubing.
5. The exhaled air will cause an equal volume of water to move through the outer length of tubing into the graduated cylinder. Record the volume of this water in ml in a data table.
6. Pour the colored water from the cylinder into the 2-L plastic bottle.
7. Repeat steps 4-6 two more times. Record the results in your data table. Calculate the average of the three readings.
8. Run in place for two minutes and exhale into the rubber tubing. Record the volume of the water in the graduated cylinder.
9. Rest for a few minutes until your breathing returns to normal. Then repeat step 8 two times and record the results. Calculate the average of the three readings.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. What do the small balloons represent?
2. What do the two ends of the straw to which the balloons are attached represent?
3. What does the longer piece of straw represent?
4. What do the sides of the cup represent?
5. What does the balloon sheet over the cup's opening represent?
6. What happened to the small balloons when you pulled down on the balloon sheet?
7. What happened to the small balloons when you pushed up on the balloon sheet?
8. What happens in the plastic bottle as you exhale into the rubber tubing?
9. Why is it important to measure the volume of exhaled air three times before and after exercise?
10. How does your average volume of exhaled air before exercise compare to your average volume of exhaled air after exercise?
11. What effect does exercise have on the volume of exhaled air? Explain.

Conclusion:

Students will understand the basic anatomy and physiology of the respiratory system. Also, students will understand that exercise will effect the volume of air exhaled.

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Fingerprints--2 mini-teaches and a game

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Objectives:

The main objectives of this mini-teach are to have K-6 students learn:
how to make and preserve fingerprints,
the basic types (arches, loops, and whorls),
and sub-types (tented arches, ulnar and radial loops with the open end of the loops pointing toward the arm's ulna or radius bones) of prints,
to understand the causes and the uniqueness of fingerprints and
to establish rapport with the students at the beginning of the year.

Materials Needed:

for first mini-teach:
pencils, paper and scotch tape.
for the second mini-teach which begins at strategy 7 below:
several feathers or 1 for each child
small jar of talcum powder
small jar of graphite powder
scotch tape
clean, clear, plastic glasses or clean jars (baby food jars are durable and have many other uses),
black and white construction paper, pre-cut into 2" x 1" rectangles,
plastic straw to serve as a teacher's super-small spoon to spoon out above powders in portions smaller than the word "no" at one portion per child.

Strategy:

1. **For the first mini-teach** draw a rectangle on your paper that is about 2" long and 1" wide.
2. Turn your pencil on its side and color the rectangle as black as you can.
3. Rub the tip of your thumb or the tip of 1 finger on the black rectangle until it is gray.
4. Put a small piece of scotch tape on the gray area of the finger in a smooth manner, usually from the tip down or from the first joint up.
5. Holding only the tip of a corner of the tape, peel it off and carefully put it on the paper. Write down what hand and finger it came from.
6. Instructions to students: "Write your name and room number on the paper. Take it home tonight to give to your mother.
7. For those who are finished early-- draw your fingerprint patterns and label the types."

8. **For the second mini-teach**: instructions to students, "Rub your finger on your nose for 2 seconds to get more oil on your finger.
9. Do not touch the cup you are going to get until I tell you how. Put one hand inside the cup to hold it still. Use the other hand to make a fingerprint on the outside of the cup.

10. Can you see it? Now dust or tap less than 1/2 cm of talcum of graphite powder on the print.
11. Use the bottom 1/2 of the feather (the part closest to the quill) to spread the powder evenly over the print.
12. Blow off any excess powder.
13. Take a small piece of scotch tape and put it on print, as in #4 above.
14. Lift off the tape thereby lifting the print.
15. If you used talcum powder, put it on the black construction paper. If you used graphite powder, put it on white construction paper.
16. Examine the print.
17. Classify it as to type and subtype.
18. Draw your print and label its classification.
19. Tape your print to your drawing."
20. GAME: send a detective(s) out of the room and put a print(s) on one or more objects. The detective(s) must find the prints and identify the person(s) to whom they belong.

.

Performance Assessment:

The grade for the print should be put on or near the print and the grades for the drawing and the classification should be put on the drawing.
Students will put their drawing in their science portfolios with their science notes which answer the following questions:

1. Is every print different? Yes.
2. How many prints does the FBI have? 21/2 billion.
3. How many pore holes does a thumb have? 900-1100.
4. Can they be used by measuring their location and number as additional ways of classifying the prints? Yes.
5. How many sweat and oil gland openings are in a finger? Do some reading.
6. Can you be convicted by the edge of a footprint or a handprint? Yes.

Conclusion:

Students will understand that fingerprints are important in solving crimes, identifying lost and/or dead people and in reuniting relatives.

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MuscleMania

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Objectives:

This mini-teach is designed for middle-school students. Through observation, demonstration and brainstorming, students will learn the three different types of muscles and their functions. By building a model of the arm, they will learn its basic anatomy and how muscles, particularly the bicep and tricep, function in relationship to bones. Students will perform an experiment on the relationship between muscle size and muscle fatigue.

Materials Needed:

[for groups of three students]
(10) Pre-prepared wooden upperarm and forearm (humerus, radius & ulna), attached to each other with (5) hinges; each set containing (4) nails or screws in anatomically correct positions
(10) Oblong balloons
(5) Markers
(5) Gallon milk jugs filled with water - weight approx. 8 lbs.
(5) Tape measures
(5) Pre-prepared charts
(1) Chicken/cow cardiac, smooth and skeletal muscles
(15) Copies of arm exercises

Strategy:

Visuals: a large "MuscleMania" banner draped across the front of the class and pictures of weightlifters taped near the students' workstations.

Demonstrate movements that the three types of muscles (cardiac, smooth and skeletal) enable us to perform. The student-demonstrator will jump up and down (skeletal-large muscles), frown (skeletal-small muscles), and eat (smooth). Discuss the continuous beating of the heart (cardiac), and introduce the concept of voluntary (skeletal) and involuntary (cardiac, smooth) control. Pass around the chicken/cow cardiac, smooth and skeletal muscles so students can see and feel the difference between these three types of muscle. Skeletal muscle is striated, cardiac muscle is somewhat striated and smooth muscle has no striations. Also observe the anatomical relationship between skin, fat, muscle and bone. Dispel the myth that muscle can "turn into" fat, or fat into muscle. Discuss contraction and relaxation and have each student perform different types of contraction (tonic, isotonic, isometric).

Students will construct an arm, with bones and muscles, using wooden sticks, balloons and nails. Distribute the "bones" (two 11/2" x 11/2" x 12" sticks attached by a 180 deg. hinge) to groups of three students. Observe how the bones move. Attach the balloons, about 50% full of air, to nails/screws in the bones. Observe where the muscles are attached and how they move with the bones. Be sure to use the terms origin and insertion. Move the whole apparatus and observe how the muscles look when they contract and relax. Using the model, identify terms of movement (abduction, adduction, supination, pronation, flexion and extension). Add striations with a marker and observe how they change in appearance with contraction and relaxation.

Now that students have a basic understanding of muscle anatomy, they will perform an experiment on the relationship of muscle size to muscle fatigue. Remaining in their groups, students will measure each other's bicep muscle by making a muscle, palpating the boundaries, and measuring between the boundaries. Chart the measurement in metric. Then one student will pick up the gallon jug with his/her dominant hand, hold it by the handle, and lift the jug up and down, keeping the elbow as close to the waist as possible. To ensure uniformity, the student will recite, "the rain in Spain stays mainly on the plain"; on "Spain" lift the weight to the shoulder and on "plain" bring the weight down towards the thigh. Be sure to tell the students not to rest between flexion and extension. Muscle fatigue will occur when the person is unable to lift the jug. Another student will count and chart the number of lifts, and measure the muscle after exercise. When all the groups have finished charting and exercising, they will discuss and decide if larger muscles fatigue more or less quickly than smaller muscles. They should also note the change in muscle size before and after exercise. Once each group's hypothesis is finalized, come together as a class and discuss the results. Ask questions concerning factors which make muscles stronger, e.g. diet, general physical condition, etc. Ask students if they moved their hips or shoulders while lifting the jug. Also look at the weightlifters and discuss the concept of size versus strength.

Finally, distribute copies of arm exercises and encourage students to develop their muscles.

Performance Assessment:

Excellent grasp - this student can define and identify the following terms: skeletal, cardiac and smooth muscle; involuntary and voluntary control; tendons, origin and insertion; abduction, adduction, flexion and extension; striation; tonic, isotonic and isometric. Muscle and fat are not interchangeable. Muscles are attached to bones and move in relationship to bones. Some muscles contract and relax synergistically, and cells of the muscles change in appearance. Muscles fatigue and change in size when a person exercises. Muscle size may/may not have anything to do with strength.

Fair grasp - this student can define and identify some of the above terms. Muscles are attached to bones, and they relax and contract. Muscle and fat are not the same thing. Muscles fatigue and change in size when a person exercises. Muscle size may/may not have anything to do with strength.

Poor grasp - this student understands that there are different types of muscles. Muscles move with bones, and relax and contract. Muscles get tired when a person exercises. Muscle size may/may not have anything to do with strength.

Conclusions:

We use muscles when we walk across a room, eat and digest an apple, or simply live.

References:

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Various pictures of exercises and weightlifters from **Glamour** and **Muscular Development, Fitness and Health**

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Breathe In, Breath Out

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Objectives:

Student will see that plants take in carbon dioxide.
Student will see that plants need sunlight to absorb carbon dioxide.

Materials Needed:

aquatic plants
bromthymol blue 0.01%
water
straws
test tube rack
grow light
dropper
saran wrap
test tubes OR clear plastic cups

Strategy:

1. Label test tubes or cups with A, B, C. Put 5 cm of water in each. Use dropper to add several drops of bromthymol blue. Mix.
2. Place a straw in test tube A and blow as you exhale. When the solution turns yellow, stop.
3. Break off two pieces of the aquatic plant and place one piece each in test tubes A and B only. Plant must be covered by the solution. Seal the three test tubes with saran wrap.
4. Put test tubes A and C in very bright sunlight or under a grow light. Put test tube B in a dark place.
5. Check the test tubes for a color change after 20 minutes. Make a record of the results.

Test tube	**Beginning Color**	**Ending Color**
A	____________	______________
B	____________	______________
C	____________	______________

Performance Assessment:

Students will be able to answer the following questions:
1. What gas was released when we exhaled as we blew into the bromthymol blue solution?
2. Why did the solutions in the test tubes change color?
3. At the end of the experiment, what happened to the solution in test tube A? Why? Test tube B? Why? Test tube C? Why?

Conclusion:

Green plants take in carbon dioxide while in the presence of sunlight.

Objective:

Students will demonstrate that plants release oxygen and water vapor during photosynthesis.

Materials Needed:

soil	spiderwort plants (wandering jew)
test tubes	microscopes
aquatic plants	microscope slides and cover plates
water	2 liter pop bottle
coleus plants	clear plastic cups
dropper	sunlight or grow light

Strategy:

1. Tear off the leaf of a spiderwort plant in a circular direction to expose the lower transparent layer of the leaf. Place it on the microscope slide, put a drop of water on it, then cover it with a slide cover. Examine it under the microscope to find the stomata (holes through which CO_2, oxygen, and water vapor enters and exits the leaf).
2. Place a few aquatic leaves in a test tube of water. Turn it upside down into the clear plastic cup of water. Place it in the sun or under a grow light. Watch for the release of tiny oxygen bubbles.
3. Cut about 2.5 inches off of the top of a 2 liter bottle. Take the black opaque bottom off. Fill the bottom with soil. Put a rooted coleus plant in the soil. Water lightly. Turn the clear top upside down over the plant. Place the terrarium in sunlight or under a grow light. Observe the release of water vapor as it collects on the sides of the bottle.

Performance Assessment:

1. Describe the leaf's stomata or draw a picture of it. Are they opened or closed?
2. Why did we need sunlight for test tubes? terrariums?
3. What would have happened if the test tubes or terrariums had been placed in a dark place?
4. What gases are released during photosynthesis?
5. Describe oxygen. Describe water vapor.
6. Explain how the respiration process in plants and animals benefit each other.

Conclusion:

Green plants release oxygen and water vapor in the presence of sunlight.

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Listen To Your Heart Beat

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Objectives:

To determine normal pulse rate
To determine factors that cause the pulse rate to change
To construct a graph to show variation in pulse rates
To construct a simple stethoscope

Materials Needed:

pumping heart
tape recorder
exercise tape
stethoscope
scissors
paper towel tubes
chart paper
markers
clay
watch with second hand
10 funnels
4 jump ropes
plastic tubing (different sizes)

Strategies:

- Have students place their right hand over heart. Describe what you feel? Using an exercise tape or record that involves body movements, allow students to exercise for 2-3 minutes. Describe and compare differences in heart beats (orally).

- What is the strongest muscle in your body? Why do you think this is so? The teacher will use a pumping heart to explain and demonstrate the function of the heart.

- You can listen to a heartbeat, but you have to feel a pulse. Your pulse can be converted into a visual display. Give each student some clay and a matchstick. Roll a ball of clay about the size of a dime. Stick a match vertically into the ball. Place it on your wrist. Shift it around until you find the spot with the strongest beat. Describe and explain what you see.

- Show the class a stethoscope. What is this? What is its function? Let each child listen to his/her heartbeat. Describe what you hear. The first stethoscope was invented in 1819. It was nothing more than a hollow tube. Place the following items on a table: paper tubes, rubber or plastic tubing of various sizes and shapes, different size funnels, cut away plastic bottles, paper cups and plastic cups, clay, scissors, tape. Give several students the opportunity to make a stethoscope (Stethoscopes must be functional). Were some items more appropriate than others? Why? Can you think of other items we can use?

- Divide class into groups of five.

  Give each group a working stethoscope; five activity cards with the following words: napper, jumper, walker, twister, jogger, and a watch.

- Each student will select an activity card and take turns exercising for 2 or 3 minutes. Count the heart beats for 15 seconds immediately after exercising. Then multiply by 4 to find the beats per minute. (Be sure to listen for the 2 part sound "lub dub" that is counted as one beat. Record results.

	Gr. 1	2	3	4	5
Napper					
Jumper					
Jogger					
Walker					
Twister					

Performance Assessment:

- What is the hardest working muscle in your body? Why ?
- Explain how the heart functions.
- Outline the circulation of blood through the heart.
- Describe the sound of a heartbeat and explain the functions of each.
- What causes the pulse?
- Did exercise cause the pulse to increase in rate or decrease? Explain.
- What did you learn from the data on the bar graph? How did the data differ among the groups? Explain?

Conclusion:

The heart is about the size of your fist. It is made of muscle. Your heart works like a pump. You hear two sounds during every heartbeat. Doctors call them lub-dub noises. Your pulse tells you how fast your heart is beating. The throb you feel is the blood rushing through the vessel with each heartbeat. During exercise your heart beats faster. When you stop, your heart rate slows down.

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Internal Anatomy: A Fun Look At The Digestive System

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Objectives:

To introduce, identify, and explain the functioning of some body parts.
To construct a "living doll" composed of the body parts discussed.

Materials:

Plastic tubing
Baggies
Yarn
Sponges
Fabric
Place Mats
Paper plates

Strategy:

Using student bodies, students will stand, breathe in and out. Point out the movement of their chest area moving in and out and let them know that their lungs are performing this action. Repeat for primary students.

Students will jog in place. When given oral command, students will run in place. After this activity, students are directed to feel their hearts.

Instructor, using food items and/or "fun" materials, will construct a doll and introduce, identify, and, explain function of body parts.

For example: yellow squash is shaped like the stomach; bananas will represent lungs; pasta shells will be small intestines, and so on with food items that approximate shape of inside body organs.

Students will construct their own doll using fabrics, sponges, and place mats to make up the body parts. This will be a permanent reminder of how some of their inside body parts are placed inside of them to perform the activity they are responsible for doing.

Performance Assessment:

Students have made their own toy. They have a workable machine. They can see and feel the different textures of materials used for the body parts. Those different feelings will aid them in the placement of the body organs.

Evaluation:

1. Students were able to place body parts on doll.
2. Students were able to identify body parts.
3. Students were able to discern that it takes the working together of all parts to make our bodies run.

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Aspects of Individual Human Blood Pressure

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Objective:

Student will:

1. Demonstrate the relationship between hypertension and the risk factors.
2. Demonstrate how pressure builds up in clogged arteries.
3. Measure both systolic and diastolic pressure by a sphygmomanometer.

Materials needed:

blood pressure cuff kit (sphygmomanometer/SFIG-moe-muh-NOM-e-ter)
plastic tubes with differing diameters
gameboard, bingo style, with risk factors in grids. Boards do NOT need to match each other. (fatty diet, lifestyles and environment, stress, inherited tendency, alcohol intake, overactive adrenal gland, street drugs, caffeine, obesity, kidney disease, diabetes, lack of exercise, smoking, excessive salt intake, cholesterol, other medications, sex, age, race)

Strategies:

Activity 1: Make gameboards with identifying words associated with hypertension (high blood pressure). Teacher calls out words from cards, first blackout "wins" a small prize. Repeat 2 or 3 times for reinforcement.

Activity 2: Using different diameter tubes, have the students compare and contrast the change of flow with a smaller tube vs. a larger one. Await them to make the association to the blood vessels. Would more pressure make the flow as fast as the larger tube? Why?

Activity 3: Using the blood pressure kit, demonstrate how to take systolic (upper) pressure-the first number at which you hear a beat after "pumping" above 200. Allow for individual sensitivities. 180 may be high enough for most. Listen to the beats, but notice the number at which you hear the LAST beat (diastolic). Systolic number is the upper number, diastolic, the "down" number. Average, or normal pressure is 120/80. Chart the class by teams, allowing for individual preference of volunteering information.

Extension activities: Is there a difference in blood pressure if seated? Lying down? After activity? Why? Students can research influencing factors as reports. Comparing diets before and after the blood pressure studies may be of interest.

Performance assessment:

Students will demonstrate ability to take blood pressure by measuring the two levels of pressure, systolic and diastolic.
Students will become more aware of the external and internal influencing factors on blood pressure.

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Reliability Of Your Visual Sense

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Objectives:

Students will:

(a) perform a series of tests on the reliability of their visual sense.
(b) record their observations for each test.
(c) conclude from their data how reliable their visual sense is.

Materials needed:

colored pencils or crayons:
 (yellow, green, red, black)
white unlined paper
pencil with eraser
protractor
paper clip opened
lightweight cardboard
glue
straight pin
3 x 5 file card
ruler

Strategy:

Activity A. Afterimages

(1) With colored pencils or crayons, color the four squares. Use only the color indicated for each square.

(2) Stare at the cross in the center of the colored squares for 30 seconds.

(3) Then, stare at a white unlined sheet of paper.

(4) Observe the colors that appear on the white paper and the position of each colored square.

(5) Closing your eyes for one or two seconds while staring at the white paper will help intensify the colors or cause them to remain visible for a longer period of time.

(6) Repeat the previous three steps as many times as necessary in order to identify each color and its location.

(7) Record the color appearing for each colored square.

Activity B. Color Wheel

(1) Cut out disk and glue it to thin cardboard. Trim the cardboard around the disk, and with a pen, attach the disk to a pencil eraser.

(2) Spin the disk in one direction by striking the disk's edge with your finger as rapidly as possible.

(3) Note the appearance of colored bands. Record the specific color bands and location of each band.

(4) Spin the disk in the opposite direction and again note and record the colors and location of each band.

Activity C. Ambiguous Figures

(1) Look at the ambiguous figure. Determine whether you see a series of cubes piled on top of each other toward the left side or toward the right side.

(2) Look again at the diagram; look continuously for at least 30 seconds.

(3) Record your observations.

Activity D. Seeing Backwards

(1) With a pin, punch a hole in the center of a file card.

(2) Look through the pinhole with one eye while holding the card about 5 cm from your eye. Look toward a light source (windows or ceiling lights).

(3) Slowly pass an opened paper clip from left to right in front of the pinhole between your eye and the card. Hold the paper clip as close to your eye as possible.

(4) Look for the shadow of the clip to appear through the pinhole.

(5) Note the direction the clip shadow moves as you move the clip from left to right.

(6) Repeat the previous three steps but now move the clip from right to left. Note the direction of the clip shadow as you move the clip up and down.

(7) Record your observations.

Analysis:

Write a brief report which explains whether or not your visual sense is 100% reliable. Draw conclusions about the reliability of your vision from the investigations performed and from other investigations with which you are familiar.

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How Air Moves In and Out of the Lung

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Objectives:

To assist pupils in the intermediate grades develop an understanding of the respiratory system.

To demonstrate how air enters and leaves the lungs.

Demonstrate the relationship between the breathing rate and exercise.

Materials needed:

1. A 1-Liter plastic bottle
2. Two 15" balloons
3. Scissors
4. Two rubber bands
5. Watch with a second hand

Strategy:

A. Background

1. Discuss and label the parts of the respiratory system always using our multicultural scientific names which are the same throughout the world. (throat, larynx, trachea, bronchial tube, air sac, lung and diaphragm)
2. Trace the path of the air through the respiratory system.
3. Discuss the process of inhaling and exhaling.

B. Activities

1. Cut the bottle in half (horizontally).
2. Place one of the balloons through the opening of the bottle.
3. Stretch the balloon opening over the bottle opening.
4. Place a rubber band over the balloon to keep it in place.
5. Cut the neck off the other balloon and stretch this balloon across the bottom of the bottle.
6. Use a rubber band to hold the balloon in place.
7. Using a watch with a second hand record the breathing rate of a person sitting (1 min.), walking (2 min.), and jogging in place (2 min.).

Performance Assessment:

Thinking of the balloon in the opening of the bottle as the lungs and the balloon across the bottom of the bottle as the diaphragm, pull down on the stretched balloon - record your finding. Pull very slowly on the stretched balloon - record your finding. Next, pull down faster on the stretched balloon- record your finding. Using the results from your findings to answer the following questions:

1. What happens to the balloon in the bottle?
2. How does air move in and out of the lungs?
3. What large muscle is important in inhaling and exhaling?
4. Does breathing rate increase with exercise?

Conclusions:

The balloon in the bottle opening fills with air when you pull down on the stretched balloon across the bottom of the bottle. When you let go of the balloon across the bottom, the air in the balloon in the opening is pushed out. Air moves in or enters the lungs when the diaphragm moves up (inhaling). Like the heart rate, the breathing rate increases with exercise.

Reference:

Mallinson, George G.; Mallinson, Jacqueline B.: Smallwood, William and Valentino, Catherine. **Science**. Morristown, N.J. Silver Burdett Company, 1984.

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The Senses: Hearing and Sight

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Objectives:

The student will understand the definition of a disability and how it affects Americans who are hearing impaired or deaf and those Americans who are visually impaired or totally or legally blind. Point out that 20% of Black Americans and 20% of U.S. Hispanics are disabled.

Materials Needed:

1. One "Hearing Experience and one" Blind Experience" sheet will be given to the class.

2. 3x5 cards will be issued to the class to record their findings.

3. One fact sheet about "Disability in America Today will enlighten the class.

4. A fact sheet on auditory and visual factors and their relationship to school success will be distributed.

5. A fact sheet on common symptoms of visual handicaps will be shared by all.

Activities:

1. Give eighth grade students a preview example of a Hearing Experience in which one experiences a lack of complete hearing by wearing ear plugs while sitting in the back seat of a car or while walking through their local Jewel Food Store. Use partners as an example in the classroom who are to wear ear plugs for a short period of time. Ask both students to write down their observations. Ask the remainder of the students to write down their findings of what they observed or thought the two sample students were experiencing.

2. Give students a preview example of a Blind Experience in which you (the teacher) walked through your classroom blindfolded with the help of an aide to prevent any problems or injuries. Have two or more students walk through your room and to the hallway with a blindfold over their eyes. While the partners are performing the experiment, ask the remainder of the class to write down their observations and impressions. When the task is completed, the students will write down on the board and on their 3x5 cards detailed observations and insights. Discuss with each student their findings and real life experiences that might relate to the exercise. Pass out sheets to everyone describing the teacher's examples of what he experienced when he performed the exercise. Compare the student and teacher responses!

Evaluation:

The teacher will assess and evaluate whether the students: 1. located relevant details of the experience by their comments and observation on their 3x5 cards;

2. recognized how the disabled (sightless or hearing impaired) adapt themselves the daily challenges of life; 3. do the exercises give you a true feeling and understanding for sightless or hearing impaired individuals who may have other handicaps which could enhance his or her disability?

Since the students are placed within the realm of a real life experience (either by participating and or observing) the assessment and evaluation gained from feedback and the excitement level of the participants will give us an immediate feeling of what we have accomplished.

Ask the question: Have your feelings, insights, and opinions changed since you went through these experiences? Recommend that students try this exercise with the aid of a parent at home. For the blind experience, use the stairs in the home to emphasize the very difficult feeling and fear the process can create! Have all the students write a three paragraph paper on their experiences for homework.

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The Investigation Of The Taste Buds

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Objectives:

(Adaptable to grade levels 1-2)
Students should identify salty, sour, bitter, and sweet tastes.
Students will investigate the sense of taste.
Students will investigate that taste buds are not uniformly distributed over the tongue.

Materials:

Cotton swabs (sterile), drinking cups (disposable), 4 beakers (400ml), water, sugar, baking soda, vinegar, salt, tooth picks, mirror and marking pencils.

Strategy:

Start by giving the students a background of the concept to be developed. Taste and smell are connected. Odors that pass from the mouth to the nose are detected and become a part of a food's flavor. Taste is affected by the texture and temperature of food. Taste buds help you taste the things you eat. A taste bud is a small structure that is sensitive to taste. There are four types of taste buds - sour (acid), sweet, salty, and bitter.

PART-I. Go over the procedure to be used in preparing and tasting the solutions. Caution students to follow sterile procedures. A cotton swab or toothpick should be used for tasting a solution and then immediately thrown into a trash container. Each student should use a new swab for each taste. Be certain the beakers or glasses used to hold the solutions are washed and have been cleaned.

PART-II. Prepare the solutions using the clean beakers. Label the beakers with the solutions A, B, C, and D.

PART-III. Dip a sterile cotton swab into solution A. Run the swab over your tongue. Record the taste of the solution in your chart. Rinse your mouth with water. Discard the swab. Using a new swab each time, repeat the procedure for solutions B, C, and D. Record your results.

OPTIONAL ACTIVITY:

Dip your cotton swab in the solutions. Touch various areas of the tongue. Use a mirror to help locate the most taste - sensitive areas of the tongue.

Performance Assessment:

After the taste demonstration, unknown food products (two types of cheeses) are passed out. Students will keep their eyes closed and use a nose plug in order to distinguish taste. Then release the nose plug and determine the difference in taste, when they are able to smell. These differences should be recorded by each student.

Conclusion:

The conclusion will be based on the results and students' interpretation. The sense organ for taste is the tongue. In the tongue are groups of nerve endings called tasted buds. When you chew food, tiny bits of it enter the taste buds through openings in the tongue. Taste buds for each of the four tastes are located in different areas of the tongue. Taste buds that respond to sweetness are on the tip of the tongue. Some of the taste buds for saltiness are also there. At the sides of the tongue are located the taste buds for sourness. Taste buds for bitterness are at the back of the tongue.

This would be a useful multicultural activity, because it relies on participation rather than discussion.

Reference:

Home, E., Alexander, J. and Edward V. **A Sourcebook for Elementary Science.** Chicago: Harcourt Brace Jovanovich, Publishers, 1971.

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How the Body's Immune System Responds to a Virus

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Objectives:

1. Students will be able to make and explain illustrations that show how viruses can appear as foreign invaders in the blood.
2. Students will be able to show how certain cells can recognize and attack the foreign invaders in the blood.
3. Students will be able to show and explain how certain cells can track down and devour the virus.
4. Students will role play how the immune system responds to a virus.

Materials needed:

1. Large red cloth
2. Construction paper
3. Chalkboard
4. Double sided magnets
5. Markers
6. Scissors

Strategy:

A. Background:
   1. Discuss the meaning of the human immune system.
   2. Discuss what the human immune system consist of and where it is located.
   3. Discuss how the healthy body's immune system works. Use the chalkboard and other bulletin board drawings.
   4. Discuss approximately when and where the AIDS-like virus was discovered.
   5. Name some viruses that can break down the body's immune system.
   6. Draw and cut out the following large letters in multicolors.
   7. The letter V will represent the VIRUSES.
   8. The letter T will represent the T-CELLS.
   9. The letter B will represent the B-CELLS.
   10. The letter K will represent the KILLER CELLS.
   11. The letter A inside a circle will represent the ANTIBODIES.
   12. The letters "SOS" will represent the emergency call sign.
   13. One child should be the narrator for the role playing.

Performance Assessment:

1. Three children will place their VIRUS signs on the red cloth which represents the BLOOD.
2. One child will place his/her T-CELL sign on the blood and scream out "VIRUS-VIRUS."
3. Three more children will appear with their T-CELL signs and place them around the VIRUS sign.

4. Two of the children who had the T-cell signs will place the "SOS" signs around the virus and scream out "Emergency-Emergency, B-CELLS, KILLER CELLS."
5. The child with the T-CELL sign begins the attack on the virus.
6. A child with a B-CELL sign comes first and, with an arrow, shoots the A-ANTIBODY at the virus which binds to the virus.
7. Three children with the K signs (KILLER CELLS) move around the blood, track down the viruses, then DEVOUR THEM.
8. The children should remove the VIRUS SIGNS and thus ends the virus in the blood.
9. Everything goes back to normal with one exception, the ANTIBODIES stay in the blood. The antibodies remember the VIRUS and are ready to attack immediately, should the virus ever appear again. Therefore, once you get a disease, you are immune from getting it again.

Multicultural Aspects:

AIDS - Acquired Immune Deficiency Syndrome is a disease that breaks down the body's immune system, which is the body's defense against disease. Therefore, making a person vulnerable to opportunistic infections.

AIDS infects all ethnic cultures. The latest research indicates that all ethnic groups around the globe are evenly divided in their involvement with this disease.

References:

1. **Resource Unit for Family Life Education**, 1988. The Board of Education of the City of Chicago.

2. **The Software Toolworks Illustrated Encyclopedia (TM)** (c) 1991 Grolier Electronic Publishing, Inc.

3. **Library in a Book: AIDS**, Flanders, Stephen A. and Carl N. Copyright 1991 by Stephen A. Flanders and Carl N. Flanders.

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The Female Reproductive Organs

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objectives:

This presentation is designed for boys and girls between the ages of eleven and fourteen. The lesson is geared to identifying the female pelvic organs and to understanding the changes that occur during puberty and what specific organs are involved in these changes. The lesson will show the path of the human egg cell during fertilization and non-fertilization and explain the process of menstruation.

Materials:

Overhead projector
Plexiglass model
Balloons
Transparencies
Information charts
Activity sheets
Question box
Chalkboard
Markers
Video tape and VCR

Strategy:

1. Have the class blow up balloons to show state of change.
2. Begin board activity with words that denote change (SEASONS, BALD, DAY, HUMANS).
3. Use transparencies to show and explain different parts of the female reproductive organs. The students will trace the journey of the egg from the ovaries on the plexiglass model.
4. The students will view a video on puberty and discuss its contents.
5. The class will review, on the chalkboard, those changes that occur in the female.

Performance Assessment:

The students will be able to define terms associated with changes that occur in the female. The class will be able to trace the passage of the egg cell during fertilization and non-fertilization. Student will be aware and understand those physical changes that occur during puberty.

Multicultural:

Students from all ethnic groups will encounter or experience physical change. The changes will vary but the concept is the same for all ethnic groups throughout the universe.

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The Sense Of Touch

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Objective:

Given a group of objects the learner will identify each using the sense of touch.

Materials Needed:

Hands-On Box	Spiny Spurs
Rocks	Sand
Ball	Water
Wood	Clay Dough
Balloons	Metal
Plastic Cup	Styrofoam

Recommended Strategies:

1. Discuss the sense of touch and name ways in which the sense can be used. Tell how the sense of touch is special.
2. Explain how the sense of touch works together with the sense of sight.
3. Place items in the Hands-On Box and have a few blindfolded students identify an object using only his/her sense of touch.
4. Place like objects on a table and have a few blindfolded students identify the same object as in the box.
5. Allow students to examine objects as to texture, shape, and size from the above list. Also as to condition of touch sensation; pain, cold, hot, or sharp.

Performance Assessment:

Give each student a worksheet and have them identify each object using the sense of touch. The students' hypotheses may vary but the idea is that the use of touch is vital in recognizing most things.

Conclusions:

As a result of the demonstration, the students will be able to realize the importance of the touch and sight senses. They will be able to use these senses in many ways.

Multicultural:

Touching objects to achieve familiarity is an aspect for many children's game in many cultures. It is an important sense for everyone because the touch sense works together with the sight sense. Everyone needs the sense of touch in many aspect of life. Touch can be used in games, skin sensation, identification, and other usage.

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The Tongue...A Sense of Taste

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Objectives:

Students will be able to identify the four taste sensations: salty, sweet, sour and bitter.
Students will be able to recognize the papillae or receptors on the tongue.
Students will be able to locate and label the different taste sense organs on the tongue.

Materials needed:

This list is for a class of thirty first grade students.

1 cup of sugar
1 cup of coffee
1 cup of salt
2 lemons
15 stalks of celery
30 tongue diagrams
30 data tables

4 sticks or cotton swabs per student
4 small cups per student
30 small hand mirrors
30 paper plates
1 quart of lemon water
1 quart of sweet water
1 quart of salty water
1 quart of water-diluted coffee

Strategy:

1. Give each student a paper plate divided into five sections. On the plate place the following items: a pinch of salt, a lemon wedge, a dash of sugar and a dash of coffee. Have the students taste each item and identify each item as being either salty, sour, sweet or bitter.
   Distribute bite size pieces of celery, ask the students to chew the celery thoroughly. (This will cleanse the mouth.)

2. Distribute a mirror to each student. Have them look at their tongue. Help them identify the papillae (receptors) on the tongue.

3. Give each student a data table, four small cups, a piece of celery and four sticks or cotton swabs. Pour 20 milliliters of the salty water in a cup, 20 milliliters of sweet water in a different cup etc., until each student has a sample of each solution.
   The cups should be labeled: A B C D or 1 2 3 4.
   The student will dip one stick in solution A, touch the four locations on the tongue as shown on the diagram on the chalkboard. The student will then record his/her sensation at each location as either salty, sour, sweet or bitter on a Data Table. The student will then cleanse his mouth using the celery. This activity should be repeated for each solution.

4. Distribute a diagram of a tongue to each student and have him/her label the areas of the tongue where the taste sensation is the greatest.

Editorial note from Dr. Porter Johnson added on July 24, 2000: Current research has indicated that all areas of the tongue seem to be equally sensitive to different tastes. See articles in Discover Magazine for more details.

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What Is Blood and How It Circulates In and Out of the Heart

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Objective:

At the end of this mini teach students should be able to explain what blood is and explain the circular movement of blood going in and out of the heart.

Materials Needed:

Crayons,a paper model of the heart, glue, stethoscope, a pump with a one way valve, attached tubing of the correct size to snugly fit a large hand bulb, a diagram of the heart showing continuous circulation.

Strategies:

Students will be given the opportunity to listen to their heart beat and to take their pulse rate.

Teacher will explain and describe what blood is and how it moves in a circular path in and out of the heart.

Students will be given a simple riddle on the functions of the blood in which they will be asked to guess what it is.

After students have answered the riddle, an explanation for taking their pulse and listening to their hearts will be given in reference to the blood circulating in and out of the heart.

Evaluation:

Students will be asked to paste the heart onto the baby diagram and use their red crayon to trace the circular path of the blood in and out of the heart looking at the teachers model.

Conclusion:

At the end of the mini teach I would like for my students to be able to explain what blood is and to trace the circular path of the blood going in and out of the heart.

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Skeletal System And External Body Development Of A Full Term Fetus

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Objective:

Grade level: 9th
Students will learn that growth of a full-term fetus' skeletal system and external body parts become more detailed and distinct throughout the three trimesters of pregnancy.

Materials needed:

(for a class of 25 students):

balloons
a picture frame
toy model car
handout (Fetal Development)
handout (outline of fetal body)
illustration poster (Fetal Development)
miniature size skeleton
paper cut-outs (Skeletal System and external Body Parts-eyes, eyebrows, nose, and mouth)
index cards (5x8)
scissors
glue

Strategy:

Optional: A toy model car and a picture frame used with key words **support** and **build** can be used to introduce the lesson. A toy model car can represent the Skeletal System and External Body Parts. A picture frame can represent the Skeletal System.

Full-Term Fetal Development: Skeletal System and External Body Parts will be presented to the class in the three trimesters (consist of approximately three months each and feature descriptions will be given of each individual month) of pregnancy.

Various Fetal Development handouts (process of conception and detailed fetal development pregnancy months 1-9) and a Fetal Development illustration poster will enhance the lesson.

Lab Activities:

Individual:

1) The class will construct a model of the skeleton of a full-term fetus. Provided are parts of the skeletal system of a fetus. You are to construct this model on a picture of a full-term fetus.
2) The class will apply the following external body parts (eyes, eyebrows, nose, and mouth) to a picture of a full-term fetus.

Group:

1) Each student will be given a balloon to place under their garment. This activity will give each student an idea of how it feels and looks to be

pregnant.

2) **Gestation (pregnancy) Trivia Game**:

a) Three groups needed: 1st, 2nd, and 3rd Trimesters.

b) Each group will be given an envelope containing three strips of paper for three random months of a full-term pregnancy. Feature facts pertaining to the Fetal Skeletal System and External Body Parts Development will be underlined for each month.

c) Each group will write a total of five feature facts (pertaining to the fetal skeletal system and external body parts) from each random month on the index cards, and write the group name on the back of the index card.

d) Each group will select an index card from a trimester other than their own. Each group will have one minute to correctly identify the correct the month to which the feature fact belongs. If the group incorrectly answers the question, the next trimester group has the opportunity to immediately answer. Each group can gain one point for each correct answer. The group with the most points after all the index cards have been selected wins the game.

References:

The Facts of Life, Jonathan Miller and David Pelham, Viking Penguin Inc., 1984
A Child's World, Sally Wendkos Olds and Diane E. Papalia, Mc Graw - Hill Co., 1990
Biology, Neil A. Campbell, Benjamin/Cummings Inc., 1987
A Child is Born, Lennart Nilsson, Dell Co., Inc., 1977

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The Adverse Effects of Birth Control on the Female Anatomy

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Objective:

For Grade levels 9 -12

At the end of this mini teach students will be able to explain the adverse effects of birth control on the female anatomy. Students will also know the correct terminology of the female anatomy and the various functions of each organ.

Materials Needed:

A model of the female anatomy, a detailed chart of the female anatomy, current birth control methods available on the market today, pamphlets Choice or Chance, HCG Pregnancy Tests, balloons.

Strategies:

Students will define the various parts of the female anatomy.

Students will label the parts of the female anatomy on the model and play birth control trivia.

Students will write down the most effective and ineffective birth control methods available today.

Students will be given four random samples of urine in which to perform the HCG Pregnancy Test. There will be one positive sample, one artificial sample, one control sample, and a negative sample.

Students who receive a positive result will be pregnant for the day.

Conclusion:

The purpose of this mini teach is for the students to learn the correct terminology of the female anatomy and its functions. Students will also learn the pros and cons of birth control.

References:

Miller Jonathan and Pelham David, **The Facts of Life**, Viking Penguin Inc., 1984.
Campbell, Neil A., **Biology**, Benjamin/Cummings Inc., 1987.

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The Brain Reflex System And How It Works

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Objective

The students will learn the basic facts about the reflex systems of the brain.

Materials needed

Rope
Penlight or flash light
Rubber hammer or special hit with hand.
Bottles (for balance)
Large paper bags

Recommended Procedure

Teacher will explain and demonstrate the procedure of all materials.

The brain is the major commander of body movements. The motor area of the brain controls the hundreds of different muscles, so that we can run, walk, talk, write, jump etc.

The brain has many different parts, but today we will concentrate on a part of the motor area.

Motor Area Parts

Motor pathways relay messages from the cortex, midbrain, and cerebellum which commands activity in muscles and glands. The midbrain is the most highly developed part of the brain.

Motor Apparatus in cells that acts directly on muscles and glands, putting them to work. These cells carry the brain's commands to the rest of the body.

Brain divisions-Cerebrum -Largest part of the brain. Cerebral Cortex-The twisted, wrinkled, and knotted surface of the cerebrum Cerebellum-Functions in the control of all kinds of movement. It "programs" the coordination of the many individual movements that go to make up actions.

Teacher can explain to the students that there are many ways to enhance their learning abilities, i.e., playing games. Here are some games that the instructor might use.

Games

Eyetoss
Knee Reflex
Mirror-Bag Game

Balance

The procedure of the games

Eyetoss-Hold a thin sheet of plastic with both hands in front of the eyes, have someone toss a ball at the persons' eyes. Ask the student to tell the reaction of his/her eyes.

Knee Reflex- The student will sit, and another student will hit the sitting students knee with the side of the hand, or a piece of rubber hose, ask the student to explain what happened.

Mirror Game-First darken the room, then ask the student to close his/her eyes for a few seconds, then open the eyes with a flashlight shining directly in the eyes. Ask the student to explain the reflex action of the pupil.

Balance- Use a rope to draw an outline of a human body on the classroom floor, then give each student a sheet of paper which has the names of the body movement of muscles i.e., brains, spinal cord, nerve spinal cord. Have each student throw and hit a student on the leg, or arm, and the students to move according to the message sent back from the brain.

This will truly be a very good learning process.

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Using Your Senses

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Objectives

To use your senses in identifying unknown substances.

Apparatus and Materials

1. Nutmeg
2. Cloves
3. Cardimis
5. Grits
6. Baking Soda
7. Carrot Juice
8. Spinach
9. Corn Meal
10. Lime Gelatin
11. Banana Nectar
12. Parsley Flakes
13. Light Corn Syrup
14. Vinegar
15. Fennel

Supplies

Santa Hat
Blackboard and Chalk
Lab. Sheet
Petri Dishes
Cotton Swabs

Substances other than the ones listed may be substituted.

Recommended Strategy

(Phenomenological Approach)

1. Review the following terms: Observation, Identifying characteristics, Categorized.

2. Discuss the meaning of the word Observation using a "gimmick" which will help lead into discussion on methods used in "Observing things". Students responded positively to the use of a Santa Claus Hat worn by the teacher. The teacher may use any object that will help initiate the "Observation Process."

3. Senses identified and used by students during class discussion and Lab Experiment are the following:

   (a) Seeing
   (b) Hearing
   (c) Tasting
   (d) Smelling
   (e) Feeling

4. Students worked in groups of 3's in observing substances listed under **Apparatus**

Materials using the senses listed above.

5. Each group of students will receive eight substances to observe. Students will record results on a prepared Lab-Sheet.

Lab-Sheet:

Things you should Observe and Record:

Number of substance used
Color
Odor
Taste
Texture
Name of substance?

Class Evaluation:

Students will discuss "Observations" and "Substance Identification" after the experiment has been completed.

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The Human Ear

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Objectives

1) The student will develop a better understanding of the human ear.
2) The various parts of the ear will be demonstrated using phenomenological apparatus.

Equipment and Materials

Model of the human ear	Clear rubber tubing
Funnels	Food coloring
Balloons	Salt
Rubber bands	Rope
Hanger	Tape recording of various sounds
Nylon	Straws (Optional)
Shell	Slinky (optional)

Recommended Strategies

Begin the lesson by a quick review of the human senses. Display the model of the human ear and begin to break it down into its various components.

Using a rope (or a slinky) demonstrate the motion of sound waves as they enter into the ear. This may be done by having two students volunteer to hold an end of the rope. Have them begin a wave-like motion with the rope and use this demonstration to start a brief discussion on the physical properties of a wave (ie. crest, trough, frequency & wavelength).

The next step is to explain the function of the eardrum. This is accomplished by using a funnel apparatus. A balloon should be placed over the large end of the funnel (held taut by using a rubber band). On the small end of the funnel a piece of clear rubber tubing should be attached (straws may be attached to the tubing for hygiene purposes). Grains of salt are then placed on the top of the balloon. Into the rubber tubing, high and low pitched sounds should be made. This demonstrates the vibration of the eardrum by a range of frequencies.

The semicircular canals may be shown by molding clear rubber tubing into a circle and filling it approximately half way with colored water. By moving the tubing around the students can be shown the way the semicircular canals are able to balance.

A shell may be displayed to show the shape of the cochlea and a hanger molded into a circle and covered with a nylon may be used to demonstrate the oval window. The rubber tubing may then be used again to represent the auditory nerve which leads to the brain.

At the end of the demonstration/explanation of the parts of the ear a tape of common sounds may be played. The students will then have to use their listening ability to determine the cause of the sounds that are on the recording.

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How Do Toxins Affect the Human Body?

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Objective:

The learner will be able to identify toxins contained within household products.
The learner will be able to determine specific affects that toxins may have on the human body.

Apparatus Needed:

Household items such as bleach, spray disinfectants, various aerosol sprays, ammonia, and other liquid cleaners.
An empty plastic bottle, cotton, and chicken livers.
Overhead projector, chart of the human body, transparency showing the human body systems, and worksheets on human body systems.

Recommended Strategy:

Put enough cotton to half fill an empty plastic bottle. Then insert a lit cigarette into the opening of the plastic bottle. Squeeze the bottle so that the cotton becomes stained with the nicotine. Then explain that these are toxins that affect the lungs of the body. Ask the question: What are toxins?: Write definition on the board. Toxins are poisons that could damage the human body. Then ask the students to think of things around the house that might contain some toxins that could affect our body on the inside or outside. Write the responses on the board. Then ask the class how they could identify these items as toxic. Explain and show that the labels give warnings that the chemicals therein could be harmful to certain parts of our body. Therefore, it is always important to read labels before using these products. Also explain that the odor of some chemicals can indicate possible harm that it could cause to the body. Show the students various household products and explain that each one could have harmful effects on our human body systems. Also, the effects of gasoline fumes for several days on a checken liver can be shown. Then compare it to a healthy chicken liver. Now show the students a transparency of the human body. Explain that each system is performing a specific job. Go over the terms of the various systems that are working within the body system. Let the students underline the following terms and take turns reading aloud the definition for each system from their worksheet:

skeletal	muscular
circulatory	respiratory
nervous	digestive
urinary	reproductive

endocrine lymphatic
skin

Let the students color each system a different color to distinguish each system and its specific job.
Then ask the students to write one or more key words that relates that system to his or her own body function.
Example: skeletal - bones, muscular - muscles, circulatory - blood.
Then ask students which body system does smoking affect? (respiratory)
Does smoking have a short or long term effect on the body? (long term)
What effect does an insect bite have on the body? (short term)

Evaluation:

Let students get into pairs, and make a list of short term and long term effects that toxins might have on the human body systems.
After about fifteen minutes, make a list on chart paper of the minor or major illnesses that result from short and long term effects of toxins on the human body.

Extension:

Each student will select one or more systems, and tell in his own words briefly how that system performs within the human body.

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Cardiorespiratory Fitness

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Objectives:
To understand and determine the pulse rate;
To compare the pulse rate before and after exercise;
To use pulse rate recovery time as a measure of fitness;
To approximate a measurement of lung capacity;
To compare lung capacities of males and females, active and inactive;
To learn how to take and compare blood pressure readings.

Apparatus Needed:
Clock or watch with second hand, wet spirometer, if available, round balloons, string, meter sticks, sphygmomanometers and stethoscopes.

Recommended Strategy:
Pulse
1. Discuss the meaning of pulse and pulse rate. Show students how to take the pulse rate in wrist, neck or temple. Time the students as they count their pulse for 30 seconds. Have the students multiply the 30 second pulse rate by two, record the number of beats in 60 seconds. Repeat two more times, and record the average in a data table.

2. Have the students work in pairs, with one taking and recording the pulse, and the other acting as subject. Have the subject stand up and sit down twice every 5 seconds for 3 minutes. Immediately take the pulse for 15 seconds, multiply by 4, and record the post-test rate. After 15 seconds, take another 15 second pulse rate, compute and record the one minute pulse rate in a data table as the 30 second recovery rate. After another 15 seconds rest, take another 15 second pulse, and record the 1 minute recovery rate. Wait 45 seconds, take a final 15 second pulse, and record the 2 minute recovery rate.

Scoring Your Pulse Rates

Rates	Good	Satisfactory	Fair to poor
Resting rate	44-62	64-80	82-100
Immediate Post test rate	80-100	104-134	136-156
30 second Recovery rate	64-84	88-116	118-140
1 minute Recovery rate	56-76	78-108	110-132
2 minute Recovery rate	56-76	78-108	110-132

3.Discuss student scores, using analysis questions.

Lung capacity

4. Define vital capacity, the maximum volume of air that can be exhaled forcibly following the deepest possible inhalation. Also, define the lung volumes that add up to the vital capacity: tidal volume, inspiratory reserve volume, and expiratory reserve volume. As you define each term, demonstrate it with a spirometer. If a spirometer is not available, demonstrate how it would be measured by exhaling in the manner appropriate for each volume. Discuss the range of average values, and the factors which influence these values. (The average adult male vital capacity ranges between 2.8 and 5.5 L.)

5. Have students compare their vital capacities, males vs. females, athletic students vs. non-athletic. Have students inflate a round balloon with the maximum amount of air that can be exhaled after a forcible inhalation. Measure the circumference of the balloon at the widest point by wrapping a string around it and measuring the length of the string. Have each student record his measurement in a data table on the board, with separate columns for males, athletic and not, and for females, athletic and not.

6. Discuss the results and the analysis questions that apply.

Blood pressure

7. Define blood pressure, systolic and diastolic. Develop the concepts by questioning the students about the cause and function of blood pressure.

8. Show the sphgmomanometer, describe the parts, and demonstrate how to use it. Have students answer handout sheet on the steps in using the apparatus.

9. Have students practice taking their lab partner's blood pressure and record the results on the board.

10. Discuss hypertension, variables affecting blood pressure, average and normal values.

11. Have students plan and execute experiments affecting blood pressure or pulse rate, such as: running in place, isometric exercise, breathing into a bag, holding the breath. or submerging one hand in cold water.

Analysis questions

1. Account for the pulse change with exercise.
2. Why is a slower pulse rate considered better than a fast one?
3. Why would a rapid recovery rate be a sign of fitness?
4. What are some variables that determine lung capacities?
5. How could you account for the different lung vital capacities in your classmates?
6. What is normal blood pressure for your age? How does your blood pressure compare to your classmates' blood pressure? Explain.

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What's Covering You? and why?

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Objective:

The student will be able to describe the four functions of the skin.

Apparatus/Materials Needed:

1. Microprojector (optional)
2. Microscopes (if available)
3. Overhead projector
4. Skin slide
5. Model of the skin
6. Transparency of the skin
7. Crayons
8. Construction paper
9. Toothpicks
10. Plastic gloves
11. Paper cups
12. Water
13. Pepper

Introduction:

The skin is an organ consisting of tissues structurally joined together to perform specific activities (functions). The four main functions are: (1) Protection: The skin covers the body and provides a physical barrier that protects underlying tissues from physical abrasion, bacterial invasion, dehydration and ultraviolet radiation. (2) Maintenance of body temperature: The production of perspiration by sweat glands help to lower body temperature back to normal. (3) Excretion: Not only does perspiration assume a role in helping to maintain normal body temperature, it also assists in excreting small amounts of water, salts and several organic compounds. (4) Perception of stimuli: (sensitivity) The skin contains numerous nerve endings and receptors that detect stimuli related to temperature, touch, pressure and pain.

Procedure:

Before you introduce lesson to your students, make sure the students have one of each of the following: paper cup, toothpick, and a plastic glove. Pour one half cup of water in each cup and sprinkle pepper in the water. Write the title "What's Covering You? and Why?" on the blackboard. Ask the students if they can figure out what is going to be discussed. Hopefully, "the skin" will be their response.

Use the following phenomenological approaches to teach the four functions of the skin.

1. **Protection:** Have the students put on one glove and stick their fingers into the water with pepper. Have the students pretend the glove is representing their skin. Now have the students take their fingers out of the water after a few seconds. Ask what happened? Have the students leave on their glove while you discuss what happened.
2. **Maintenance of body temperature:** By the time you finish discussing function one, the students hand with the glove should be warm and somewhat sweaty. Have the students take off the glove and wave that hand in the air. Now ask what do they feel? Discuss. 3. **Excretion:** Function two and three are somewhat alike. Include in your discussion that excretion is more than letting out a waste. Have the students express their opinion of excretion and the taste of perspiration.
4. **Perception of stimuli (sensitivity):** Have the students take the toothpick and gently rub it on their arm. Ask what they feel? Now, have the students pinch themselves (gently) and turn to the person next to them and touch them. Ask what do they feel? Discuss response.

After you discuss the four functions, show pictures of the skin using the overhead projector, microprojector and model. Pointing out the sweat gland. Inform the students that they have two sections within the skin; the outer (epidermis) and inner (dermis) section. Within the sections are other layers. As independent practice have the students take a sheet of paper and fold it to make four squares. Then have students use crayons to draw a picture representing each function. After completing the activity, pass out colored sheets of the skin showing the outer and inner sections of the skin.

Vocabulary

protection	perspiration
excretion	bacteria
gland	temperature

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To Have Or Not To Have Oxygen (Part I - Fermentation)

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Objectives:

1. The students will be able to describe the process of glycolysis.
2. The students will be able to infer the reactants and products of fermentation.

Materials:

1 liter bottle	grape juice	sauerkraut
7 large styrofoam balls	large balloon	ethyl alcohol
28 small " "	sour milk	bacteria slide
acetic acid	litmus paper	colored circles
3 microscopes	yeast	shredded cabbage
chicken leg	2.5% salt solution	lactic acid
pipe cleaners	waterbase paint	yeast slide
muscle slide	yogurt(optional)	grapes(optional)

Recommended Strategy:

1. Color: 6 large styrofoam balls light blue on one side and dark blue on the other to represent glucose.
   1 large styrofoam ball dark green to represent oxygen.
   4 small styrofoam balls red on one side and pink on the other side to represent adenosine.
   12 small styrofoam balls yellow on one side and brown on the other side to represent phosphate.
   4 small styrofoam balls dark green on one side and light green on the other side to represent NAD.
   8 small styrofoam balls brown to represent hydrogen.
2. Connect: the 6 glucose balls with pipe cleaners
   an adenosine ball with 3 phosphate balls to make ATP (2)
   an adenosine ball with 2 phosphate balls to make ADP (2)
3. Make up student model packages using colored circles that match the styrofoam balls. This can be done for 6 teams.
4. Set-up: Students will bring answer sheets to each set-up and work as a team.

Set-up I. Add a package of yeast to the grape juice in the liter bottle and place the large balloon over the neck of the bottle 3 days ahead. Place in a dark area. On the day of the lesson place the fermented grape juice with the inflated balloon, the microscope with a yeast slide, and a labelled 50 ml beaker sample of ethyl alcohol. As an added treat you can have two or three grapes in foil for each of the students to sample.

Direction sheet: Read all directions first!

1. Test the ethyl alcohol with litmus paper. Is it an acid or base? (Blue to red = acid; red to blue = base).
2. Use your senses to observe the set-up. Which senses should you

not use?

3. Examine the yeast slide under the microscope. Do not move the slide. Use only the fine adjustment knob.
4. List your observations of the entire setup.
5. Decide which reaction is represented.
6. Prepare to move to Set-up II. Remove your waste. You may sample the grapes.

Set-up II. Ten days before the lesson add shredded cabbage to a clear quart container and fill the jar with a 2.5% salt solution. Label the container Homemade sauerkraut. Place a jar of commercial sauerkraut some samples of which have been placed on foil for the students to taste, the microscope set up with the bacteria slide, a sample of shredded cabbage, a 50 ml beaker of 2.5% salt solution, a 50 ml beaker of acetic acid. Optional: plain yogurt, cheese, and tofu can be displayed.

Direction Sheet: Read all directions first!

1. Test the acetic acid with the litmus paper. Is it an acid? (Blue to red = acid. Red to blue= base).
2. Examine the Homemade sauerkraut. You may taste your commercial kraut samples. Use toothpicks to lift your sample from the foil.
3. Examine the bacteria slide. Do not move the slide. Use only the fine adjustment knob.
4. Note the other examples present. List your observations about the entire setup.
5. Decide which reaction is represented.
6. Prepare to move to Set-up III. Remove your waste.

Set-up III. 5 days before the lesson, begin souring a pint of milk. On the day of the lesson, pour the liquid off of the clots into a 50 ml beaker and label. Place the skinned chicken leg (displays muscle tissue) on foil; set up the muscle slide; pour lactic acid in a 50 ml beaker; and place a heavy book at the setup.

Directions Sheet: Read all directions first!

1. Test the lactic acid and sour milk with the litmus paper. Are they acidic or basic? (Blue to red = acid; red to blue = base).
2. One member of the team should hold the book with the arm extended as long as possible. Explain to your classmates how your arm feels.
3. Examine your chicken sample. What type of tissue is predominant (seems to be the most abundant)?
4. Examine the muscle tissue slide.
5. List your observations of the entire setup.
6. Decide which reaction is represented and where this reaction takes place.
7. Prepare to move to Set-up I. Remove your waste.

Lesson Presentation: Request all handouts from writer.

1. Review the students by using the overhead projector and a review sheet which will prepare the students for the lesson.
2. Pass out the lesson sheets 1-3.
3. Sheet 1 will be used to demonstrate the process of glycolysis by using students and the styrofoam balls. The teacher will represent the enzymes.

4. Sheet 2 will be used to demonstrate the possible reactions during Fermentation according to the organism, and also give instructions for the phenomenological activities the teams will perform.
5. Sheet 3 will contain the activity 3 questions 1-5, and homework questions.

Team Activities: Teams will start at their number and rotate to the next higher number every ten minutes. Team 6 goes to 1.

1. Do the vocabulary matching quiz; 2. Use your models and handout sheets to review the process of glycolysis and fermentation; 3. Answer questions 1-5; 4. Set-up I; 5. Set-up II; 6. Set-up III

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The Bone Connection

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Objectives:

1. The student should be able to list the functions of the human skeletal system
2. The student should be able to name some bones in the human skeletal system and at least one function of each

Apparatus Needed:

1. Model of a house under construction (made out of popsicle sticks)
2. Parts of the skeleton (cut into puzzle pieces and placed in an envelope)
3. A rag doll, A doll with a stand, A model of a skeleton
4. A bone cut in half (uncooked chicken or turkey bone)

Recommended Strategy:

1. Show the class a model of a house under construction and pass out a ditto sheet with a picture of a house under construction.
2. Ask students if they can give the purpose of the framework of a house (expected response: Acts as a support for the house)
3. Ask students if they can explain the system in the human body that has a similar function (expected response: The skeleton)
4. Show the students a rag doll and a doll supported by a stand. Ask them why is it that the rag doll can not sit up, but the doll supported by the stand can and why they can sit up in their seats? (expected response: The skeletal system supports the human body and the stand supports the doll, but the rag doll has no support system.)
5. Ask the students to describe how the skeleton differs, if at all, from the frame of a house (expected response: the skeleton is made of living substance.)
6. Pass out activity 2:3 (the student will fill in the body part and the number of bones in each using the model of the human skeleton to count the bones.)
7. Activity 2:4 (Mastering Concepts: similar bones, different function, example: arm and leg bone (humerus) is similar to the leg and foot bone (femur) but they have different functions)
8. Have the class move their finger over their skull to feel the extent (ask if any one can think of the function the skull serves)
9. Give some background information on the long bone of the leg, include that it provides the greatest possible strength with the least possible weight. (roll a piece of note paper and secure it with a rubber band and place a book on top of it. To show how the legs support the body weight. Cut the bone to show marrow

(explain).

10. Give some background information on the muscle (include that bones are moved at the joints by muscles (show a cardboard model of the arm with a balloon attached for muscle and tape as the tendons). Explain further (biceps, triceps, etc.).
11. Pass out the skeleton and let the student assemble it, label the parts and give the function of each.

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Nutrition

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Objectives:

1. To test samples of food to find out if they contain fat.

2. To test fruit juices for vitamin C and compare the vitamin C content of the juices.

3. To calculate the number of calories per day that you eat.

4. To learn what information is given about food on a label.

Materials:

1. unglazed paper (brown paper bags) food samples; margarine, butter, peanut butter, cheese, bacon, banana, salad dressing.

2. Methylene blue solution-dissolve 0.1g of methylene blue powder in 10ml ethanol 4 test tubes, dropper, fruit juices: orange, lemon, grapefruit, lime.

3. Calorie charts, food list from activity.

4. 10 different food labels, paper pencil.

Strategy:

1. a. Hold a piece of unglazed paper up to a light. Notice whether or not light passes through the paper.

   b. Rub some fat or oil on the paper. Hold the paper up to a light. Notice any change in the paper.

   c. This smear test is the test for fats. Test samples of margarine, butter, peanut butter, cheese, bacon, banana, and salad dressing to see if these foods contain fats or oils. Record your observations.

   d. Try other substances that are suspected not to contain fats.

2. a. Add 10ml of methylene blue solution to a test tube.

   b. Use a dropper and add a drop of fresh orange juice to the test tube. Gently swirl the test tube.

   c. Continue to add orange juice to the test tube one drop at a time. Swirl the test tube after every addition. Count the number of orange juice needed to change the color of the solution from blue to colorless.

d. Record this number.

e. Repeat steps 1-3 using lemon juice, grapefruit juice, and lime juice.

f. Record the number of drops of each juice needed to turn the methylene blue solution colorless.

3. a. Use the calorie charts and the food list from activity. Calculate the number of calories per day that you eat.

   b. Use the calorie charts to write balanced meals for one day.

4. a. Collect the labels from 10 of your favorite processed foods.

   b. Fill in the blanks in your data table with the information to each food.

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GENETIC VARIATIONS IN HAND SPAN SIZE

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OBJECTIVE:
Students shall measure their handspan size to determine if one pair or many pairs of genes control that trait.

MATERIALS:
Metric rulers, Basketball, Lab. Worksheet, Graph paper, and Graphic overlays.

STRATEGIES:
Obtain a metric ruler, lab. worksheet and graph paper. Measure your handspan size as demonstrated by teacher, spreading out your hand on a sheet of paper. Draw a line from the tip of your thumb to the tip of your little finger. Do not include length of fingernails. Measure the length of the line (your handspan) in millimeters. Record the measurements of all members of your class on the chalkboard. Organize the measurements into a graph showing handspan size in groups of 5 mm. Also record the number of students in each group. Draw a graph of the data in the table. Then carry Basketball out to students to see if students can place handspan across the Basketball and hold in place without touching any object. Next, answer the following questions:

(1) What does the graph reveal about the differences in handspans within your class?

(2) Based upon these data, do you think size of handspan size is controlled by one or more pairs of genes?

(3) What other factors can affect hand size?

Conclusion: If a genetic trait is controlled by a single pair of genes, then class results would usually show only two categories or groups. When a genetic trait is controlled by several pairs of genes, a number of different groups will appear. Therefore, this genetic trait must be controlled by more than one pair of genes.

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COMPARISON OF RESPIRED AIR VOLUME

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BEHAVIORAL OBJECTIVES:

1. Students will see a comparative difference in volume lung capacity.
2. Students will understand that a relationship exists among many sciences.

MATERIALS;

1. Posterboard (to construct calipers.)
2. Metric rulers.
3. Overhead projector.
4. Balloons.

STRATEGIES;

Introduce lesson by comparing respiration systems from organisms that are simple to organisms that are complex.
As man manifests complexity in all systems, so also is his respiratory system. Compare internal and external respiration.

DEMONSTRATION & LABORATORY:

1. Vital Capacity.
   - (A) Stretch balloon.
   - (B) Inhale a deep breath and exhale into your balloon.
   - (C) Use calipers to determine balloons diameter in centimeters.
   - (D) Record information in column labeled vital capacity.
   - (E) Record four additional trials.
2. Expiratory Reserve.
   - (A) Take a normal breath, exhale normally and expel the remainder into your balloon.
   - (B) Measure and record.
   - (C) Record four additional trials.
3. Tidal Volume.
   - (A) Breath normally and exhale into your balloon without disrupting your pattern.
   - (B) Measure and record.
   - (C) Record four additional trials.
4. Statistics.
   - (A) Transfer balloon diameters in centimeters to cubic centimeters by using the graph on your work sheet. (Volume)
   - (B) Record these volumes.
   - (C) Compare class data.
   - (D) Compare data for all classes.
   - (E) Compare data for men and women.
   - (F) Compare other combinations of interest.

CONCLUSION:

1. Air has volume, is matter, and can be measured.
2. The differences in respiration among humans can be determined.
3. Biological evolution appears to develop from the simple to the complex.
4. There is an obvious association among the sciences.
5. The students understand and can define:
   (A) Vital capacity.
   (B) Expiratory reserve.
   (C) Tidal volume.
   (D) Internal respiration.
   (E) External respiration.

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THE EYE AND COLOR IMAGES

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Objectives: 1) To have the student to observe and experiment with visual after images.

2) To have the student observe white light and its component color spectrum.

3) Introduce the student to the basic colors and their complements within the visual system by demonstration.

4) Introduce the basic parts of the eye.

5) To demonstrate how the optical path and focal system work.

6) To demonstrate how an image is projected upon the retinal network.

7) Show feature analysis of illusions produced by after images.

8) To show the student how to derive any given color.

Materials: Candle, convex lens, overhead projector, color light box, 3 by 5 index cards, envelopes, small triangles (red, blue, green, and yellow), drawings or pictures, matches, and model of the human eye.

Strategies: Pass out envelopes containing four different colored triangles and an index card. see below

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Have the students in the class place a red triangle in the center of the circle. (Make sure that the student concentrates on looking at the triangle for at least 45 seconds). When the time is up have them stare at the dot on the other end of the card.

2

You should ask them if they see anything unusual as they are staring at the dot. ans. (A blue after image). Wait six minutes then have them try another color on the card. Each time they should see an after image of the complementary color(s). If you have students that don't seem to see the after image, show them the handouts I gave you or pictures from **Human Information Processing** page 216a thru 216d. This may them to see the phenomena and identify the colors.

Light box=PA & Triangle= chalkboard

The color light box should be used at this point. Show the complementary colors, and the white color produced when the three basic colors of light are added together. The triangle of colors should be put on the overhead also, to show the student to derive the other colors and their complements. **NOTE** The room should be dark.

Image=PA

Take the candle and put it about two feet in front of the object you would like to project your image upon. Light the candle. Take the convex lens and move it back and forth between the candle and the screen until you find the focal point. (The candle image should now be projected on the screen in full living color, upside down). This is the time to pull out the model of the eye and show them how the eye works.

These PA's should lead to all sorts of wonderful discussions about photochemicals and proteins, eye structure and function, images and after images, component colors of white light, and colors and their complements.

References

Lindsey, Peter, and Norman, Donald. **Human Information Processing.** New York: Academic Press, 1973.

Otto, James, and Towle, Albert. **Modern Biology** New York: Holt, Rinehart and Winston, 1977.

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Biology/Chemistry

Embryology: From Egg To Chick

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Objective(s):

1.) This lesson will teach students the value of living animals.

2.) This lesson is for first grade students.

3.) This lesson will build student knowledge of basic biology, especially embryology and anatomy.

4.) This lesson illustrates similarities of biological functions in all animals.

5.) This lesson will increase awareness of the value of laboratory animals to science.

Materials:

We will use one incubator with hydrometer, thermometer, distilled water, Chlorox bleach or rubbing alcohol (for cleaning the incubator), chicken feed, lamp with a fifteen watt bulb, one dozen fertilized eggs (obtain them from a distributor), one dozen of regular store bought eggs, transparent plates or saucers, flat wooden sticks or Popsicle sticks to probe the unfertilized eggs, freezer bags (one gallon size) for disposal of raw egg waste, vinegar and transparent disposable cups (16 oz. size).

-

Strategy:

We want to get the fertilized eggs to hatch by putting them in an incubator for twenty-one days with an average temperature of 99.5 degrees Fahrenheit and maintaining an average humidity of about 51%. Secondly, we want to examine an egg on the inside and outside to help identify the parts of an egg. This can be done on regular store bought eggs. Examine an egg in a saucer or plate. Identify the important visible parts of the egg by breaking it open and physically inspect these parts with a Popsicle stick. Use another egg to investigate the shell components by putting eggs in transparent cups with vinegar. Use just enough vinegar to submerge the whole egg. Students will inspect and draw what happens over the next few days. On the fifth day students may inspect and observe the egg with the shell dissolved away (the acetic acid in the vinegar dissolves the calcium carbonate of which the shell is made). We will inspect the egg embryos by candling the eggs. A candler can easily be made with a flashlight and an empty box. We will use an empty Huggies baby wipes box. You can inspect the eggs with the candler to predict the number of eggs that will hatch. Cut a hole in the bottom of the Huggies box. The hole should be about half the diameter of an egg. Place an egg on the hole and illuminate it from below with the flashlight. Inspect the eggs every day or every few days (up to the eighteenth day) to see the stages of development.

—

As the eggs are incubating it will be necessary for the students to go through some daily lessons. The Cooperative extension Service of The University of Illinois at Urbana-Champaign College of Agriculture along with the 4-H Club has issued a workbook to help inculcate the objectives of this lesson. Since I have a mobile unit that goes from classroom to classroom I concentrate on the more salient lessons and the homeroom teacher works with the daily lessons. These lessons include:

"I is for incubator. We set the eggs in an incubator. The incubator is the mother hen for the eggs. Today we set the incubator. We will have chicks in 21 days. Count with me." Use diagrams of the developmental stages of the chick to help the children see what is happening inside the eggs each day.

"T is for thermometer. If the temperature in the incubator goes higher than 103 degrees F., the eggs will not hatch. If the temperature is below 99 degrees F., the eggs may not hatch on time."

"E is for egg. My shell is usually white or brown. Eggs are rich in protein, minerals and vitamins. Eggs are good at all meals and as snacks. Color my shell. When you open me what do you find? Draw what is inside me. Draw the inside of the egg."

"Where am I?" labels the parts of the egg. "Identify the air cell- I am at the large end of the egg. Thin white—I am near the shell. Thick white—I am nearest the yolk. Yolk—I am yellow and feed the embryo. Chalaza – I look like a rope and hold the yolk. Shell – I am hard. Outer shell membrane – I am closest to the shell. Inner shell membrane – I am next to the white. Germ Spot – I am where the chick begins to develop. Vitellin Membrane – I am between the yolk and white."

"H is for hen. A hen is an adult female chicken. I lay eggs. Before I am one I am called a pullet."

"R is for rooster. A rooster is a male chicken. A male chicken under one is called a cockerel."

"C is for chick. A young female chick is called a pullet. A young male chick is called a cockerel."

"A chicken is a bird. I have a comb on my head. My comb is red. How many legs do I have? Find my bill. My bill is yellow."

Performance Assessment:

Students will be able to answer these questions with 80% accuracy.

1. We put the eggs in an _______________.
2. The chicks hatched in _______________ days.
3. The chicks were placed in the ____________.
4. The female chick is called a _____________.
5. The male chicken is called a _____________.
6. The baby chicken is called a _____________.
7. How many parts of an egg can you name?

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8. How many parts of a chick can you name?

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9. We feed our chicks ________ and ________.

Conclusions:

-

This exercise will introduce students to the process of reproduction in animals emphasizing the parts of animal eggs (and the function of each) as well as the stages in development from fertilized egg to baby.

-

References:

4-H, A Member's Manual for the Study of Incubation and Embryonic Development (available from the Illinois Cooperative Extension Service).

You may also call Sandra Lignell at 708-352-0109 or Tim Kristakos at The Museum Of Science and Industry in Chicago at 312-684-1414 for further information about this topic.

Mathematics/Physics

Be A "Peder-Reader" - A Discovery Activity

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Objective(s):

To learn about the millipede's physical structure and characteristics by observing its behavior in given activities. Pupils will hypothesize whether they think the millipede will make an interesting pet for them or not.

Materials Needed:

two(at least one per eight pupils) giant millipedes; one worksheet per group; primary balance scale; masking tape; metric ruler or tape measure; mirrors; paper plates; dried fruit bits (e.g., raisins); leaf litter; medicine droppers with water; box of washers; magnifying glasses; Instant Hand Sanitizer; assorted materials for millipedes to crawl upon, such as a styrofoam square, a straw fan, a wicker plate and a piece of nylon screening; Kool-ade packets; one **K-W-L** chart per group; rubber gloves (optional)

Strategy: (Activities are five minutes each)

#1. Choose a "Peder-Leader" for each group of "Peder-Readers," who will gently handle the critter and lead the group in filling out the worksheets. Use gloves if you like. One member of the group will record group responses on their K-W-L chart - what you already know about millipedes and what you want to know about them. As you make your rounds to each station, the recorder will fill out the section of the chart labeled - "What I Learned……"

#2. Discuss with your group how long it takes your critter to uncurl and start to "explore." Using a magnifying glass, "read" its body and name your critter. Can you estimate how many legs and segments it has? Discuss with one another whether it sees, smells, tastes, hears and feels. Do this before going to Station #1.

#3. Go to Station #1.

Name your millipede and "read" the millipede's moves. You're now going to observe its manner of getting around. Does it "glide", "sway", "stretch", or "crawl"? Brainstorm with your "Peder-Peers" and see how many verbs you come up with to describe how it moves. Get the styrofoam square, the nylon screening, the straw fan and the wicker plate. Place your critter on it. Can it defy gravity? Turn the critter upside down and note what happens. Imagine among yourselves what Sir Isaac Newton would say about millipede's laws of motion.

#4. Go to Station #2.

Place four to five raisins, some leaf litter, and some dry Kool-ade at various places on a paper plate and allow your millipede to crawl at will. Can you determine if it has a preference? If so, tell how.

Have a group member take the dropper and drop some water on the millipede. Is there a noticeable reaction? Using another paper plate, make a very shallow "puddle" with water from the medicine dropper and place the critter in the puddle. Is there any noticeable reaction? Have the recorder write your findings in the K-W-L chart.

#5. Go to Station #3

Gently place your critter in the primary balance scale and estimate how many washers it weighs. Now weigh it. Who came the closest to their estimation? Now, estimate its length and its width (around the middle segment). Take the tape measure, and measure its length and width in centimeters. (Talk softly to your millipede as you handle it). Record your findings in the K-W-L chart.

#6. Go to Station #4

Take two mirrors and tape them firmly at right angles so that they stand up on the table. Place your little critter squarely in the center of the mirrors. Does something interesting happen? Have your recorder tell how many images you see and describe the shape of your millipede. Is it symmetrical? Explain. Discuss among yourselves whether you think it can "see" its image in the mirror.

Performance Assessment:

Each "Peder-Recorder" will present their group's K-W-L chart orally to the entire class. At the end of their presentation, the recorder will state how many in their group concluded whether or not the millipede will make an "interesting" pet.

References:

Science Lab Boreal Laboratories

Biology/Chemistry

Cool Coral Reefs

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Objective(s):

Grades: K through 8

The students will be able to: 1) identify, color and label the continents of the world and the equator; 2) identify, color, and label a world map and the location of the coral reefs; 3) read about and discuss the three types of coral reefs and make samples of each; 4) identify and produce water temperature between 74 and 78 degrees; 5) identify and discuss the term polyps; and 6) construct a colony of polyps.

Materials Needed:

Cooperative groups of 6 - 1 tub of white crayola clay, colored markers, a box of Riggitoni pasta, package of 200 small paper plates, 6 thermometers, 6 plastic cups, water, 60 world maps, 25 pipe cleaners, 12 pieces of blue paper, 12 coffee cans, glue, scissors, and Scotch tape.

Strategy:

This activity will be set up into 5 stations:

Station 1

Maps: *Where in the World* and *Reefs Around the World*

Color, label and cut out each map

Cover the cans with the blue paper

Glue each map on each can

Station 2

Temperature: What is the approximate temperature of water in a coral reef? Fill a plastic cup 1/3 of the way with warm water. Using warmer and cooler water, depending on the existing temperature, create a temperature of water between 74 and 78 degrees. Use the thermometer to achieve this desired temperature.

Station 3

The three types of reefs are atoll, barrier, and fringing reefs.

Three plates with clay sculptures showing the following: a. *fringing reef* – grows outward from the shoreline; b. *barrier reef*- is separated from the land by a lagoon; c. the *atoll* - a ring of coral far out in the ocean that has a sunken island or volcano beneath.

Station 4

Polyps are animals found growing in the bottom of coral beds. Place a medium size ball of clay on a paper plate. Get four pieces of riggittoni and color each differently with a marker. Get two pipe cleaners and cut them into thirds. Take some more clay and make four small balls, place these balls on the top of the riggittoni and stick the pipe cleaners in the ball. Then, press down. Take the medium ball of clay and spread it thickly on the paper plate. Take the riggittoni and place it standing up in the clay close together, then build the clay around the colony of pasta.

Station 5

Write a group story on Paula, Paul, Pat, and Peola Polyp. Make sure the story contains important facts about coral reefs, their location, and the kind of inhabitants that inhabit a coral. Reference books on coral reefs will be available for students to research.

Performance Assessment:

Students will be assessed on the following items:

- Journal writing entries
- Examples of the three types of coral reefs
- How well the students were able to use the reference materials to enhance their group report
- Oral and written presentation of their group report
- A written quiz which can be administered individually and/or in a group

References:

Diving Into Oceans. Ranger Rick’s Nature Scope. Illustrators: Kim Kerin and Jack Shepard. National Wildlife Federation Publishing Co. 1992.

Life In The Coral Reef. Written by Bobbie Kalman and Niki Walker & Photographed by Tom Stack and Associates, Crabtree Publishing Company, 1997.

Webs of Life: Coral Reef. Written by Norbert Wu; includes photographs, Atheneum Books for Young Readers, 1996.

Coral Reef: A City That Never Sleeps. Written by Mary M. Cerullo & Photographed by Jeffrey L. Rotman, Cobblehill Books, 1996.

Sea Activities

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Bateman School
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Objectives:

This lesson has been designed for the bilingual kindergarten learner, but can be used for other grade levels 1st to 3rd.

*The students will recognize sea creatures.
*The students will learn that the sea water is salty, how to extract salt, and convert seawater into fresh drinking water.
*The students will learn that there are bodies of sea water where the amount of salt is so great that people float effortlessly in them.
*The students will learn and recognize that sea water has chloride ions.

Materials Needed:

*Group students in 4 or 6
*Mural paper, light blue, cut paper 5 foot long
*Crayons
*Sea creatures stencils
*Pencils

Strategy: Setting the stage

Setting the stage in your classroom to create a sea atmosphere. Have the students draw and create the ocean using the sea creatures stencils. After the students have finished, hang the murals created by students around your classroom. This will prepare a learning atmosphere for the student to learn about sea creatures and seawater.

Materials Needed:

*Masking tape
*Small plastic bowl
*Plastic bags large enough to hold the bowl
*Sea salt
*Tap water
*Plastic spoons

Strategy: Fresh Water from Sea Water

The light from the sun passes though the clear plastic and heats the surface of the salty water in the bowl. Although it is a simple process, extracting fresh water from sea water on a large scale is very costly. Sea water is first heated then the steam is boiled off and condensed into fresh water leaving the salt. Group the students in 4 or 6. Have the students cover the bottom of the bowl with a thin layer of sea salt. Fill the bowl one-half full with tap water and stir until all the salt is dissolved. Set the bowl inside the plastic bag and close the opening with masking tape and place the bag in direct sunlight. After 24 hours open the bag and collect the liquid around the inside of the plastic bag with a plastic spoon.

Results:

Have the students taste the liquid collected. The liquid inside the plastic bag will taste like fresh water.

Materials Needed:

*Group students in 4 or 6
*2 Large glass containers or breakers
*Sea salt, making sea water use 35 grams of salt in 965 grams of fresh water
*2 hard boil eggs
*Fresh water

Strategy: Making a egg float

To demonstrate how salt content is measured by the buoyancy force, as the salt content of the water increases. The water gets more dense and has greater buoyancy force, and the fresh water is less dense, and has less buoyancy force. Float an egg in salt water. After you have made sea water, fill two glasses, one with fresh water, the other one with sea water. Place an egg in each one of the glasses. Describe the results to the students.

Results:

The egg will rise and float in the sea water and the egg in the fresh water will sink to the bottom of the glass. This is the result of the buoyancy force, the density of the water increases.

Materials Needed:

*Fresh water
*Sea salt
*Test tube or plastic clear glass
*Medicine dropper
*Silver nitrate

Strategy: Testing for the Chloride Ion

This is a simple chemical experiment which can be easily done to test sea water for the chloride ion. Pour 25 to 30 milliliters of water into a test tube or a plastic cup. Add a few grams (three or four) of sea water. Shake to dissolve the salt. Cautiously add two to three drop of silver nitrate do not shake or stir.

Results:

The silver nitrate will react with the sea water and will turn milkly white if chloride ions are present in the sea water.

Performance Assessment:

Students should be able to:

*Answer oral questions.
*Observe the changes taking place in the experiments.

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Animals: Here and Now

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Objectives:

Elementary school students (5th-6th grade) will be able to:

1. identify basic "zoo" animals upon sight by name
2. classify animals by particular type (i.e., habits, location, size, special colorings, grouping, etc.)
3. have a basic understanding of the animal kingdom and the various classifications
4. discuss and identify natural habitats of most zoo animals
5. construct and display a small "zoo like" model
6. write a short story or diary about an animal or pet of their choice

Materials Needed:

(per group of 2-3 students)

1. 2 boxes of animal crackers
2. 1 box of crayons
3. 2-4 sheets of poster board (11" x 7")
4. 2-4 sheets of plastic screening (12" x 8")
5. 1 sheet of small self-adhesive zoo animals
6. 1 bottle of glue
7. stapler or roll of masking tape
8. twigs, grass cuttings, small leaves, etc. (for beautification)
9. scissors

Strategy:

A. Zoo model - Students are going to construct a habitat and select animals appropriate to that habitat.

   1. Cut white poster board into a piece 11" x 7".
   2. Cut plastic screening into a piece 12" x 8".
   3. Cut or peel off animal stickers.
   4. Glue, stick on, and arrange animal crackers or animal stickers randomly to 11" x 7" piece of white poster board (be sure to leave sufficient space between animals in order to add any trees, shrubbery, twigs, grass, etc.).
   5. Add anything else that may be seen in or around contained in zoo environment or setting.
   6. After all gluing, cutting, and arranging activities are completed and intact, place 12" X 8" plastic screening directly on top of 11" x 7" white poster board sheet.
   7. Attach the overlapped edges of plastic screening to back of poster board with staples or masking tape to create a "zoo" replica.
   8. Display "zoo" replica on window ledge or other appropriate locations in the classroom so that other students can view, compare, contrast, discuss and enjoy.

B. Animal game activity

1. Select a blank 3" x 5" index card for each child in the class.
2. Write various animal facts unique to one particular animal on each card.
3. Hand out one card to each child.
4. Have each child read the facts out loud to the rest of the class.
5. Once the card has been read, allow the child reading the card to correctly name the animal in question.
6. If the child reading the card incorrectly names the animal, the other children in the class get the opportunity to correctly name the animal.

Performance Assessment:

The student will be assessed according to his/her ability to:

1. construct a "zoo" replica from recent zoo visit or model that the teacher had on display for the entire classroom.
2. participate with other students in an animal guessing game.
3. perform well on a short test or quiz, focusing on animal names, types, special characteristics, habits, origins, etc.

Conclusion:

At the end of this mini-teach students should have a thorough understanding and appreciation of animal life.

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Insect Classification

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Objectives:

This lesson has been developed for 6th grade students but can be used for other grade levels.
Students will:
- learn the classification system of living organisms
- identify the general body parts of an insect
- learn insect classification into orders, families, genus and species
- demonstrate the ability to classify any given insects by using a scientific insect classification key

Materials Needed:

Colored tissue paper, cut out insect stencils, drinking straws, clothes pins, cotton balls, Q-tips, glue bottles, markers, crayons, yarn thread, napkins, scissors, paper pins, paper clips, Insect Classification Key, 4-6 packets of insect pictures for classification (each containing 12-16 pictures), paper charts, masking tape, etc.

Strategy:

In preparation for this lesson, the teacher will talk in general about insects, explain insect body parts using picture of a grasshopper and important morphological characters that form the basis for insect classification.

Part A Each student will be given all the necessary materials to make a butterfly using colorful tissue papers and attach to it appendages such as 3 pairs of legs, 1 pair of antenna, 1 pair of compound eyes following proper instructions and using appropriate materials. Every student will then identify and familiarize himself/herself with the distinct body parts of an insect. Teacher will interact as a facilitator. All the butterflies thus made will be collected by the teacher and displayed in the classroom to share the work.

Part B Students in class will be divided into equal groups of 4 students each. Each group will be provided with a standard "Insect Classification Key" with a packet containing 16-20 insect pictures for identification purposes. Students in each group will work together to identify given insects using the key and sort them into their respective insect orders. Each group will then make their own "Insect Classification Chart" by pasting the identified insects under alphabetically arranged respective insect orders with their common names written below them. Teacher will act as a facilitator. The work of each group will be collected and displayed in the classroom to share the information.

Assessment:

At the completion of the lesson, the students:

A. Can identify all the given insects using the key.

B. Can identify 80% of all the given insects using the key.

C. Can identify 70% of all the given insects using the key.

D. Can identify 60% of all the given insects using the key.

F. Cannot figure out well or at all.

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Bernoulli's Principle and Winged Flight

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Objectives:

This science "mystery" was originally presented to third graders, but is probably appropriate for grades 3-12. The objectives are (1) to see how the decrease in air pressure which occurs when air is moving (relative to air which is not moving or is moving more slowly) allows birds to fly.

Materials Needed:

wooden dowel

thread

masking tape

three ping pong balls (or styrofoam balls about the same size as the ping pong balls)

hand held hair drier

Strategy:

This lesson makes a perfect "science mystery." It starts out with the wooden dowel. Cut two pieces of thread of equal length (about one foot). Tape one thread (at one end) to one of the balls and the other thread (at one end) to a second ball. Then tape the other ends of the two threads to the dowel near one end; when this is done, the two balls should hang down from the dowel when it is held horizontally so that they are about 1/2 inch apart (horizontally) but at exactly the same level (height-wise). Ask for a volunteer to hold the dowel horizontally (so the balls hang down) and another to blow (gently but firmly) through the space between the two balls. Ask the children to predict what will happen to the balls (most probably will say that the balls will be pushed apart). Actually, if the volunteer is careful to blow straight through the space between the balls and not on the balls themselves, the balls will be pushed **together**! The increase in velocity of the air being blown through the space between the two balls relative to the speed of the (still) air on either side of the ball makes the air pressure lower between the balls than outside of them, and the balls are thus pushed together.

Then take the hair drier and turn it on (the phenomenon and explanation are simpler if the air can be blown without heat, because then you don't have to worry about changes in temperature complicating things). Holding it vertically, place a ball above the stream of air and let it go. The ball will float above the opening of the hair drier, and will be held quite well (laterally) within the stream of air. The blowing air elevates the ball and places it within a stream of air moving relative to the air outside of the stream. Thus, as above, the ball is trapped in a zone of low pressure, and the higher air pressure surrounding the stream of moving air keeps the ball from leaving the zone of low pressure.

This is also the principle of bird flight. The birds' wings are relatively flat on the bottom and convex on the top. When a bird is moving forward through the air, then, the air flowing **over** the wing has farther to go in a given amount of time than the air **beneath** the wing (the shortest distance between two points is a straight line, i.e., beneath the wing; the distance above the wing is longer because it is not in a straight line). Thus, the velocity of the air passing above the wing is greater than the velocity of the air passing beneath the wing, the air pressure is thus greater below the wing than above it, and the bird is pushed up. The same principle of "lift" allows an airplane to fly.

Performance Assessment:

Grading might be best achieved by assessment of a one page (or so) write-up of the experiment that includes accurate discussions of the results of the experiment as well as the principle behind it (the latter may be appropriate only for the upper grades).

References:

Encyclopedias (look under Bernoulli's principle)
Probably any high school or college general biology text

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Teeth Identification in Omnivores, Herbivores and Carnivores

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Objectives:

LEVELS: ALL GRADES

The main objective of this lesson is to demonstrate the differences in teeth structure and how it determines what a specific animal eats. This will be accomplished by constructing a raccoon puppet.

Materials Needed:

pictures of various animals (focusing on their mouth)
paper bags (4" X 8")
red modeling clay
corn kernels
black and brown crayons
glue

Strategy:

1. Display pictures of various animals, discussing their teeth structure.
2. Lay the paper bag flat with the flap facing you.
3. Draw a raccoon face above the flap. Allow the students to get creative with their puppets faces.
4. Turn the bag over to, allow some space at the top, then draw the raccoon's tail.
5. Lift up the flap and glue two strips of clay (one on top and one on bottom) to the bag. These should represent the gums of the raccoon.
6. Place individual corn kernels in the clay to represent the different kinds of teeth. Instruct the students to position the kernels so that the front teeth are sharp and the back teeth are smooth and round.
7. Allow the students to demonstrate the functioning of their puppets to one another.

Performance Assessment:

At the completion of these activities the students will be able to answer the following questions:

1. What do omnivores eat?
2. What do carnivores eat?
3. What do herbivores eat?
4. How do the structure of an animals determine what they eat?
5. Describe the different shapes of animal teeth.
6. Can the learner apply this information to the identification of dinosaurs?

Conclusion:

At the conclusion of this activity the students will understand the differences in teeth shapes and how this dictates the diet of an animal.

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Insects: Grasshoppers

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Objectives:

This lesson was geared for Kindergarten:

Students will learn how to listen and follow direction; to observe living things; to compare and contrast; to record and read information on a graph; to work in cooperative groups; addition skills; how to identify an insect; the characteristics of a grasshopper and the functions of the grasshopper external body parts.

State Goals for Learning:

Students will learn the concept and basic vocabulary of biological, physical and environmental science and their application to life and work in contemporary technological society.

Materials Needed:

a magnifying glass per child
a number of bugs and insects
chart paper and markers
newspaper and a roll of string
green tissue paper
green pipe cleaners
toilet tissue rolls
straight pins
scissors
glue
combs
4 rolls of tissue
clear plastic cups
green construction paper
index cards
clothes pins
masking tape
small paper fasteners
wiggley eyes
styrofoam balls
black craft pom-pom balls
hole puncher
styrofoam peanuts
styrofoam cups
clay
shaving cream

Song; (Tune to: "The Farmer in the Dell")
-- The insect in the jar
The insect in the jar
Has six legs and three body parts.
-- First you have the head
Then you have the thorax
Then have the abdomen which is connected to the thorax.
-- The head has two eyes
And a simple one too
It has two feelers to touch and smell their food.
-- The mouth has large lips
And sharp jaws in between A second pair of jaws
Which is use for tasting things.
-- The thorax has six legs
And two pair of wings

Rubbing them together is how this insect sings.

Vocabulary:

mandibles = sharp jaws
simple eye = sees light and dark
molting = process of shedding skin
thorax = chest
spiracles = airway for breathing
nymphs = baby grasshopper

Procedures:

1. Sing the song "The Insects in the Jar," allow students the opportunity to observe what they have in the jar. Then let them put their name on the chart after they predict if they have an insect in the jar or not.
2. Draw a large picture of a grasshopper on the board and label its body parts.
3. Make a model grasshopper using toilet tissue roll. (Project #1)
   A. Punch holes in the tissue rolls six on the bottom and one on the top.
   B. Cover roll with a thin layer of glue, roll tissue paper around it (same for styrofoam ball).
   C. Take pipe cleaners, cut them in half, punch cleaners through holes, entering on the right side and exiting on the left side.
   D. Cut tissue and construction paper wings, then put a hole in each of them in the same spot.
   E. Line wing holes with the hole on the top of the tissue roll then put paper fastener through the holes.
   F. Line front end of tissue roll with glue, then push the ball on it.
   G. Take black ball and put in the top center on the covered styrofoam ball, then put a straight pin through it.
   H. Put wiggley eyes on each side of the covered ball.
   I. Take short pipe cleaners and stick between the wiggley eyes.
   J. Take marker and draw on mouth.
   K. Staple back in close.
4. Make human grasshopper using oneself. (Project #2)
   A. Read a short story about grasshoppers for background information.
   B. Make a construction paper head band.
   C. Put two holes approximately 1 inch apart from each other.
   D. Put pipe cleaners through the hole to make antennae.
   E. Tape a small green oval in the center of the band.
   F. Tape to your face construction paper mouth and feelers.
   G. Stuff stockings with newspaper.
   H. Take long string and tie at the open ends of the stocking.
   I. Tie the string around your waist (this is the third pair of legs).
   J. Take chart paper, and tissue paper wings, and put a hole through the top of the wings.
   K. Put paper fastener through the holes and open it up.
   L. Pin wings to the back of the shirt.
5. Make a clay model grasshopper. (Project #3).
   Use learned skills to make clay model grasshopper.
6. Preparation for the birth and the protection of the baby grasshopper. (Project #4).
   A. Take clear plastic cup and fill with dirt.
   B. Place styrofoam peanut in the dirt, making sure to leave a side view of the peanut.
   C. Spray shaving cream on the top of the dirt which represents how the mother protects her eggs through the winter.
7. Make human nymph (baby grasshopper). (Project #5).
   Take toilet tissue and wrap your partner from head to toe to illustrate a baby nymph.

8. The various sounds of a grasshopper (Project #6).
   Rub finger nail against a comb.
   Rub two brushes together.
   Rub finger nails against styrofoam cup.

Performance Assessment:

Students should be able draw a picture of a grasshopper including all the details covered in the above three activities. Students should also be able to label each part by sounding the words out to the best of their abilities. Students will be able to answer the following questions:

Name the body parts of a grasshopper.
Identify the thorax.
What do you see on the thorax?
What do you see on the abdomen?
Where are the wings located?
Where are the feelers?
What happens when the grasshopper jumps?
Compare the baby grasshopper to the mother grasshopper? What are the similarities and differences?
Students will be able to recite poem learned about grasshoppers.

Conclusion:

Students will know the life cycle, external body parts, and the function of the grasshopper.

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Insect Inquiries

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Objectives:

LEVELS:ALL GRADES

The main objective of this lesson is to develop in the learner a curiosity about the insect world. Students will collect and observe insects native to the area.

Materials Needed:

Collection Materials
- potatoes
- knives
- spoons
- trowels
- data sheet
- masking tape
- petri dishes
- glass jars with lids
- hand lenses
- markers/crayons
- drawing paper

Model Construction
- 2' square piece of plywood
- 4 (1' by 12') wood strips
- 8 tack nails
- paint (optional)

Strategy:

Collection Technique
1. Allow the students to design their own insect. Have them draw their insect on paper and label the parts. The students must describe the function of these parts.
2. Brainstorm on the following questions.
   - What body parts do insects have?
   - Where do insects live?
   - How can we catch insects to observe?
3. Cut a potato in half lengthwise. (For younger students you may want to have this already done.)
4. With a spoon, hollow out the center of each potato half to form a cavity.
5. On each end of these cavities make identations or entrances to your potato traps. You will want to make sure that the indentations are about halfway above the center of each end.
6. Place the potato halves back together (you can wrap the halves together with masking tape) to complete the trap.
7. Locate the spot you would like to use to collect and, with your trowel, dig a depression in the soil. The area should be deep enough so that the potato traps' entrance is level with the ground surface.
8. Place the potato trap in position. Soil from the depression can be left to one side to fill in after you are through with your collecting.
9. Check your potato daily to record the kinds and number of critters in

your trap.

10. Transfer your critters to a petri dish or glass jar.
11. Observe your critters with a hand lens.
12. Record your observations.

Model Construction ROLLY POLLY DOWNS

1. Draw a circle (2" diameter) in the center of the plywood.
2. Arrange the wood strips in a spoke-like pattern around the circle.
3. Nail the strips in place.
4. Paint your model to resemble a race track. Label the model "ROLLY POLLY DOWNS."
5. Allow the students to race their critters. First one to the circle wins!
6. Remember to release the animals after you have completed these activities.

Performance Assessment:

At the completion of these activities, students will be able to answer the following questions:

1. Which animals in your trap are attracted to the potato for food?
2. Which animals are there because they are attracted to its moisture, a water source?
3. Which could be there just for shelter?
4. Could any of the animals be there to prey upon the other animals in your trap?
5. If traps were set in forests, fields, marshes, etc. would we find different animals? Are there animals that seem to live in all areas?
6. Predict what might happen if we had buried the potato deeper in the ground.

References:

Zuckerman, Karen. **One Potato, Two Potato, Three Potato Traps. Celebrating Science.** Honors Science Teachers of Illinois. 1990.
Mitchell, Andrew. **The Young Naturalist, An Introduction to Nature Studies.** London: Usborne Publishing Ltd. 1982.
Hickman, Pamela. **Bug Wise.** Reading, Massachusetts: Addison-Wesley Publishing Company. 1991.

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Wonderful Worms

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Objectives:

Primary children will be able to:

- identify living and non-living things.
- understand the importance of earthworms to the soil.
- name some basic facts about earthworms.
- recognize basic "worm" vocabulary words.
- demonstrate vermicomposting techniques.
- understand that different living things need different environments for living.

Materials Needed:

Earthworms	Shop Towels	Gummy Worms
Water	Paper Plates	Knifes
Containers	Scissors	Top Soil
Sand	Hardboiled Eggs	Acetone
Tape Recorder	Rap Tape	Worksheets
Microphone	Magnifier	Ruler

Optional Materials Needed:

Balance Scale	Terrarium	Books
Flashlight	Prism	Food Processor
Socks	Markers	Transfers

Strategy:

1. Distribute Gummy Worms. Discuss living vs. non-living things. Access children's prior knowledge of worms through discussion.
2. Distribute worms, one wet and one dry paper towel, and the following worksheets: (a) Worm Watching Guide (b) Worm Words (c) Worm Diagram.
3. Discuss the following: (a) Is your worm a living thing? How do you know? (b) What shape is your earthworm? (c) What color is your earthworm? (d) How long is your earthworm? (e) Does your earth worm have legs, eyes, ears, nose, hair, mouth? (f) Is there a difference between the top side of your earthworm and underneath? Can you describe the difference? (g) How does the worm's skin feel? (h) Do you think the earthworm has a skeleton? (i) How does the worm move? (j) Can a worm move backwards? (k) Does a worm have any special features? Describe them. (l) Does a worm prefer a wet or dry paper towel?
4. Referring to their diagrams, have the students identify where the following features are on or in their worms: (a) clitellum; (b) gizzard; (c) crop; (d) anus; (e) mouth; (f) hearts; (g) segments.
5. As background information, for the adults who may be teaching this unit to their students, discuss reproduction in a worm.

6. Distribute sheet "Wormy Activities In the Classroom". Discuss the activities described below.
    a. Write and illustrate a story from a Worm's perspective.
    b. Weigh lunch leftovers for your class after they have been chopped up by a food processor. Find out how many kilograms of waste your class produces in a day, week, month, and year. Feed chopped up waste to your worms.
    c. Share class knowledge with others by writing a newsletter.
    d. Make a Worm Puppet from an old sock.
    e. Have students make "Worms and Dirt". Crumble chocolate wafer cookies and make instant chocolate pudding. Place gelatin worms in the bottom of dessert cups, pour pudding over the top, and then sprinkle the crumbled cookies over.
    f. Make Tee Shirt Transfers or Buttons which proclaim "Worms Eat Our Garbage".
    g. Incorporate descriptive words about worms into creative writing assignments.
    h. Research the giant Australian Earthworms.
    i. Shine a flashlight through a prism so that it casts a spectrum. The worm will crawl through a red light and avoid blue light.
7. Wet a cotton ball with nail polish remover. Put the cotton ball by a worm's head. Then put the cotton ball by a worm's tail. Note any difference in the response.
8. Distribute containers. Make a vermicomposter with sand, top soil, and food waste. Put worms in containers. Feed worms and water soil on a regular basis. Observe over time.
9. Play the audio tape "Worm Rap". Have students do the "Worm Rap". The "Worm Rap", written by Caroline Haviland, can be found in the publication, **SCIENCE AND CHILDREN, JANUARY 1993**.

WORM RAP

A worm doesn't have any bones inside,
But that doesn't stop it from taking a ride.
Through the soil, Yeah, a worm is strong.
If it had to, it could carry 10 others along.

No bones, no bones, no bones, no bones
A worm has got no bones, no bones

A worm doesn't have any eyes to see,
But that doesn't mean it will bump into a tree.
It feels vibrations, deep in the ground,
And then it starts to move and wriggle around.

No eyes, no eyes, no eyes, no eyes,
A worm has got no eyes, no eyes.

A worm doesn't have any feet you know,
But that doesn't stop it from making a hole.
Deep in the soil when the rain comes down,
The worms will come out or they will drown.

No feet, no feet, no feet, no feet

A worm has got no feet, no feet

A worm doesn't have any teeth to chew,
But that doesn't stop it from eating food.
They take little bits of dirt in their mouth,
And when it's all eaten, rich soil comes out!

No teeth, no teeth, no teeth, no teeth,
A worm has got no teeth, no teeth.

No bones, no eyes, no feet, no teeth!
A worm has got no bones, eyes, feet, or teeth!

Performance Assessment:

At the conclusion of this mini-teach unit on worms, students will be able to identify living and non-living things, understand the importance of earthworms to the soil, name some basic facts about earthworms, recognize basic "worm" vocabulary words, demonstrate vermicomposting techniques, and understand that different living things need different environments for living. Different assessment techniques will be used including teacher observation, oral questioning, written tests and worksheets, crayon drawings, and drama presentations with sock worm puppets.

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Know Your Cousins - Monotremas, Marsupials, and Placentals

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Objectives:

This lesson is designed for primary students. It identifies some mammals. Students should be able to recognize characteristics of mammals. Students should be able to categorize mammal groupings. Students should be able to describe how mammals grow inside the mother's body and resemble their parents at birth.

Materials Needed:

- chalkboard
- chalk
- feely box
- hair
- fur
- eggs
- milk
- bones
- writing paper
- pencils
- glue
- crayons
- markers
- scissors
- construction paper
- animal flashcards
- animal pictures
- dice
- game board

Strategy:

The activities I devised to carry out my objectives are as follows:

1. brainstorming
2. use of a feely box
3. place mammal vocabulary words into ABC order
4. unscramble mammal vocabulary words
5. make as many words as possible from one vocabulary word
6. write Teasing Tongue Twisters about specific mammals
7. make a Strange Mammal Booklet by putting together parts of mammal pictures
8. make a shadow box with a favorite mammal
9. play Win Lose or Draw
10. play Password
11. play Concentration
12. play Know Your Mammal! (game) Make a game board using poster board and pictures of mammals. A student will start at START and move around the board by throwing a dice and landing on an animal picture. Next, the student will state if the animal is a mammal or not. If the answer is correct, the student will remain on the mammal picture. If the answer is wrong, the student will go back to start.
13. write poems
14. write stories
15. write songs

Performance Assessment:

The students should be able to identify two mammals from the three categories of mammals which are monotremas, marsupials, and placental mammals. The students should be able to state the main characteristics of mammals which are warm blooded, have back bones, have fur or hair, produce their own milk and have live births. The students should be able to identify ten mammals. The students should be able to state that mammals grow inside the mother's body, in the uterus, and are surrounded by the placenta, and resemble their parents at birth.

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A Fish Tale

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Objectives:

This lesson is designed for the primary level student.
The main objectives of this mini-teach are to:

- demonstrate how fish cells respond to fresh and salty water
- determine the age of a fish
- determine if temperature effects the movement of a fish's operculum (gill cover) and mouth
- identify the characteristics of fish

Materials Needed:

- salt
- teaspoon
- masking tape
- marker
- fish net
- ice
- large-mouthed jar
- hand lens
- fish scales (from a local market)
- dark paper
- a small cucumber
- 2 shallow bowls, 1 large bowl
- aquarium with goldfish
- thermometer

Strategy:

1. Fill both bowls one-half full with water.
2. Stir 1 teaspoon of salt into one of the bowls, label this bowl 'salt' using the tape to make the label.
3. Cut the cucumber into thin circular slices.
4. Place 3 slices of cucumber into each bowl.
5. Wait 30 minutes.
6. Remove the slices and test their flexibility by carefully using your fingers to bend them back and forth.
7. Now switch the slices, placing the ones that were previously in the salt water into the pure water, and the pure water slices go into the salty water.
8. Wait 30 minutes and again test their flexibility.
9. Place a dried scale on the dark paper.
10. Study the ring pattern on the scale.
11. Count the wide, lighter bands.
12. Fill the large-mouthed jar with water from the aquarium.
13. Use the net to transfer a fish to the jar.
14. Allow the fish 30 minutes to adjust to its new environment.
15. Count and record the number of times the fish opens and closes its mouth and operculum.
16. Place the jar in the bowl.
17. Fill the bowl one-half full with ice and then add enough water to fill the bowl. Do not add anything to the jar containing the fish.
18. Wait until the temperature in the jar reads 10 degrees Celsius and again count the number of times the fish opens and closes its mouth and

operculum in one minute.

Performance Assessment:

At the conclusion of the mini-teach, students will be able to answer the following questions:

1. What are the characteristics of fish?
   If it has scales, fins and gills-it's a fish.
2. How does fluid pass from one cell to another?
   Osmosis-water moves across the cell membrane toward where there are more dissolved materials in the water. The water moves because there are more particles of salt in the bowl than in the cell.
3. What is the effect of salt water on fish?
   Fish in salt water tend to dehydrate and they compensate for this by drinking large amounts of sea water. They excrete salt from their gills and their kidneys remove very little water from the body.
4. What is the effect of fresh water on fish?
   Water is absorbed into their cells, the surrounding water is less salty. They excrete large amounts of water through their kidneys.
5. How old is a fish?
   Fish scales form rings with each year of growth. The number of wide bands equals the age of the fish. The wider bands are formed annually, the smaller bands are formed seasonally.
6. How does temperature effect the number of times a fish opens and closes its mouth and operculum (gill cover)?
   There is more movement when the water temperature was warmer. Animals conserve energy when in a cold environment. Their body loses heat thus losing energy and movements slow down.

Conclusions:

Students will understand osmosis of cells and how to determine the age of fish. They will also be able to discuss conservation of energy in colder water and characteristics of fish.

References:

VanCleave, Janice. **Biology for Every Kid**, John Wiley & Sons, 1990.

Ward, Pat and Barbara. **Fishes: A Science Activity Book**, Mark Twain Media, Inc., 1993.

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Bird Beaks

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Objectives:

This lesson is designed for students in grades kindergarten through third. The main objective of this Mini-teach is to show students that many different birds can live in the same geographical area because they are adapted to eat different organisms.

Students will be able to:

1. Compare the feeding habits of birds to their physical traits.
2. Expain that many varieties of birds can use the same habitat for gathering food because of adapting traits (i.e. beaks).

Materials Needed:

Per class (divided into 4 groups according to beak types):

1. Scissors
2. Spoons
3. Tweezers
4. Clothes pins (chop sticks)
5. 500 pennies (washer slugs)
6. 500 round beads (marbles)
7. 2 packages toothpicks
8. Cups (one per student)
9. Chart paper and felt pen
10. Crayon and white construction paper

Strategies:

1. Introductory Information:
   1. Background:
      Previous lesson on birds
      Classification of birds by beaks
   2. Make Bird Beak Chart
2. Discussion on beaks; their shape, uses and food adaptation.
3. Two sheets of paper and crayons will be given to each student in all four beak groups.
4. Each bird beak group will draw and color the beak of their bird group.
5. Introduce game and discipline procedures
   1. Game overview: To be played outdoors in defined lawn area, size determined by teacher.
   2. Group students equally into 4 beak types (scissor group, spoon group, tweezer group, clothes pin group).
   3. Pass out "beaks" and one cup (to represent bird's stomach) to each student. Each student gets one type of beak and must keep it throughout the game.

4. Students hold beaks in hand (not mouth).
5. Feeding Procedures:
    1. Teacher throws out handfuls of penny bugs. All students will pick up "bugs" with their "beaks" and place them in their cup (no hands or scooping with cup).
    2. Students must wait for a signal to begin before collecting food. Teacher calls time to end.
    3. Students assemble in their beak type groups, put their pennies together, total, and record group total on chart.
    4. Repeat feeding procedure (above) using worm toothpicks, then bead seeds.
    5. Finally throw out all three items together as before and have the students pick up whatever they want. (By now they know what they are adapted to pick up.)
    6. Again, total in groups and list on chart.
    7, Return to class to dicuss findings.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. Can you classify birds according to the four beak types?
2. Do birds have teeth in their mouth?
3. Do birds use their beak for purposes other than eating?
4. Does the shape and size of a bird's beak decide what can be eaten by that bird?
5. Are birds adapted to certain geographical areas according to beaks?
6. Can all birds use their beak to eat any organisms?
7. How does the bird's feet help him to eat?
8. Which beaks are best adapted to pick up the different items?
9. Why can a large variety of birds eat in the same geographical area?

Conclusion:

Students will be able to understand and compare the feeding habits of birds to their physical traits. Students will also be able to explain that many varieties of birds can use the same habitat for gathering food because of adapting traits (i.e. beaks).

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Sharks

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Objectives:

This lesson is designed for students in grades two through eight.

1. The objective of this lesson is to teach the interrelationship between marine life forms.
2. Students will use role playing to demonstrate an understanding of the issues and diverse opinions people have about sharks.
3. To teach students that sharks use their senses to detect prey.
4. The students will understand that the sharks body parts help it float and make it more buoyant.
5. To show that sharks can detect blood in concentrations of 1 part per million.

Materials Needed:

28 clear plastic cups
4 measuring teaspoons
1 16oz. can of tomato juice
2 newspapers
large container of water
1 pack of construction paper
1 roll of masking tape
red crayons or pencils
10 cucumbers
10 large paper clips
30 plastic lids (drink cups, yogurt, etc.)
1 tape with announcement of shark sighting
10 pairs of scissors
10 plastic knives
1 large container (6"deep)
1 town meeting notice to post in classroom
several staplers
paint and brushes
1 roll of string
shark information cards
10 pieces of string (3"each)

Strategy:

Activity 1

1. Explain that as a class they will hold a class meeting to discuss what should be done about the shark.
2. Read the town meeting notice to the class.
3. Allow the students to choose the group they would like to represent.
4. Explain how the meeting will run.
5. Distribute role cards to the appropriate students.
6. Tell the students to be prepared to comment on other people's statements.

Activity 2

1. Have each group of students cut 20 pieces of string 12" long. Double loop them to six inches and knot the loose ends.
2. Tell the students to punch a hole in the top of each marine creature circle, and attach a string.
3. Beginning with the three top consumers, attach the strings to the ends and middle of a straw.
4. Balance the straw on your finger so the straw hangs horizontally.
5. Tape the string.
6. Attach the seal, fish, and octopus circles to a second straw.
7. Connect the loose string from the top predator level to the straw with the seal and fish.
8. Find the balance point and attach another string.
9. Continue until all levels have been completed.
10. Attach the sun to the string and hang your mobile.

Activity 3

1. Divide your class into four groups.
2. Give each group of students 7 cups.
3. Label cups with numbers 1 through 7.
4. Have the students carefully measure 18 teaspoons of water in cups 2 through 7.
5. Put 1/4 cup of tomato juice into cup number 1. (This represents blood from a wounded fish that a shark might smell in the ocean.)
6. Direct the students to take two teaspoons, of the tomato juice from cup number 1 and put it in number 2. Stir the mixture. Take two teaspoons from cup number 2 and put in cup number 3. Continue this process until cup number 7 has been mixed.
7. Have the students draw 7 circles on a blank sheet of paper to match the 7 cups. Number the circles and color them with the red crayons to correspond to the color in each cup.

Activity 4

1. Give each group of students the shark information cards.
2. Have students draw a shark, including the fins, on a piece of paper.
3. Cut out picture and use it as a pattern to make another shark.
4. Have students paint shark and add gill slits, eyes, teeth, and a mouth.
5. Staple the body shape along the edges. When partly stapled, gently stuff the body cavity with crumpled newspaper to give it shape.
6. Staple the shark on all sides.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. What senses are involved in detecting and tracking prey?
2. What is the function of the lateral line on a shark?
3. What is the lowest concentration of blood that a shark can detect?
4. What determines whether a shark will accept or reject its prey?
5. Why must all the cups have the same amount of water?
6. What do you observe about the color of water in the cups?

7. Which parts of a shark's body are essential for swimming?

Conclusion:

Students will understand that sharks use their senses to track prey. They will understand that the marine food web includes a myriad of sea creatures from zooplankton to tuna and sharks.

References:

John S. Knight and James L. Knight Foundation, **Search For The Great Sharks**, (The Cincinnati Museum of Natural History, and Graphic Films Corp., St. Paul, Minnesota, 1993).

Lynn Wilson, **Sharks**, (Putnam and Grosset Group, New York, 1992).

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Dinosaurs---Read All About Them!

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Objective:

The main objective of the Mini-teach is to introduce students to library research as an integral part of scientific research.

Materials Needed:

reference materials	dinosaur stencils
identification sheets	puzzles
construction paper	scissors
glue, tape, fasteners	hole punch

Strategy:

Station I: Using reference books provided, complete worksheets on identification of dinosaurs, their skeletal parts and footprints.

Station II: Solve rebus, addition and footprint puzzles.

Station III: Select patterns of body parts from various dinosaurs. Assemble the parts to create a new animal designed to survive better than its prehistoric ancestors. Be prepared to defend your "improvements".

Performance Assessment:

1. Self-check folders are provided at Stations I and II.
2. Paper models of dinosaurs will lead students into discussions of dinosaur forms and functions.

Conclusions:

Students will improve skills in locating and using reference materials to initiate and support scientific investigation and to locate the answers to specific questions.

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Making Your Dog Your Best Friend

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Objective:

This lesson is aimed for students of all grades to show them that hands, voice and heart is the basis of dog training and through demonstration and hands on experience, students will be able to teach a dog simple commands and to play a game.

Materials Needed:

Dog, leash, collar, handouts for class, one toy for four groups (four toys)

Strategy:

1. Students will be introduced to a German Shepard dog named Buster Brown.
2. Students will be introduced to a training collar and leash their and uses will be explained.
3. a. Students will watch a demonstration of Buster performing the basic commands of heel, sit, come and finish (recall), long sit and long down.
   b. Students will brainstorm as a group and explain how they think that Buster learned his commands.
4. Students will learn how a trainer teaches a dog to learn the commands.
   Modeling-showing the dog what you want, i.e. sit;
   a. Hands-gently pushing dogs hind quarters down for his sit while pulling up with the leash at the same time.
   b. Voice-a firm but gentle "sit" coincides with the hand command.
   c. Heart-rewards of praise and/or food.
5. a. Students will be given simple dog toys such as a ball, a tug rope, a squeak toy, etc.
   b. Students will form into groups to develop a strategy for teaching Buster to play a game.
   c. Students will explain to the class what strategy they will use to teach Buster his game.
   d. Students will teach Buster to play his game.
6. The class will discuss what they've learned about how to teach a dog simple commands and playing games.
7. The class will discuss how they learn to play games and will relate teaching Buster to how they learn.

Performance Assessment:

Students should be able to know that training a dog involves uses of their hands, voice and heart with 95% accuracy.

Students should be able to come up with a strategy to teach a dog a trick using their hands, voice and heart at 90% accuracy.

Conclusion:

That the learning process for dogs involves modeling behaviors through use of his leash and collar. Behaviors are taught through the use of hands - i.e. showing a dog what you want him to do, voice - i.e. explaining through simple commands (sit, stay etc.) and heart, use of praise, food, and tone of your voice - i.e. whether you are pleased or angry.

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Testing Fats in Food

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Objectives:

The main objective of this Mini-teach is to provide students with the opportunity to test the presence of fat in foods. Students will become more aware of their daily diet.

Materials Needed:

brown paper bag
peanut butter
margarine
cooking oil
meat
bread (white/wheat)
cheese
peanuts (shelled/processed)
activity worksheet
pencil and paper

Strategy:

Activity 1-Students were shown a brown paper bag to observe and tell what was in the bag. Students gave many different answers. The answers were written on the board, then the actual contents of the bag was revealed.

Activity 2-How can you test for fat? Cover the work area with newspaper. Rub a small sample of each material on the paper bag. Watch for any changes, record what you have observed on the activity worksheet.

Activity 3-The removal of fat from a chicken: The chicken was weighed before cutting. The chicken was cut, the fat and the skin were removed and weighed to determine the percentage of fat. The chicken was weighed again to determine the weight. Finally, the bones were removed and weighed to get an accurate weight of the whole chicken versus the non-fat chicken.

Performance Assessment:

1. Students observed changes on the paper bag when fat was present in a food.

2. Students became more aware of the important of having less fat in their diet.

3. Students discuss the facts of:
   A. Losing weight-people who want to lose weight take some fatty foods out of their diet.
   B. A balanced daily diet-nutrition and metabolism are closely related. The input into metabolism is our diet. In other words, "You are what you eat."

Conclusion:

To determine the effects of diet on growth and health requires not only doing experiments but getting a good understanding and eating a balanced diet.

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Toothpick Worms

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Objectives:

The objective of this lesson is to let students experience the role of color in camouflage.

Materials needed:

100 colored toothpicks, consisting of the same number of 4 different colors. (Colored pipe cleaners can be substituted.) Be sure to have each color counted before "seeding" the feeding ground.
1 Spring-type clothes pin (to simulate bird's beak) per child
A bucket of mud for nest formations
Disposable rubber gloves

An area of approx. 20 square meters where toothpicks of one color will blend in well. For example, a freshly mowed area for green toothpicks.

Ahead of time, prepare the feeding ground by placing EACH different color evenly throughout the area, as well as sticking them in the ground vertically. CAUTION: have all participants wear thick-soled shoes as the toothpicks do pose a safety hazard.

Strategy:

1. Tell the students that they will be playing a game in which they will become birds. These birds have only one source of food-toothpick worms.
2. Remind each group of 4 students that they will have to build a nest to which they will bring their worms. Review previous lesson on nest materials. The Field Museum has Habitat boxes in the Harris Center for loan. Order 2 weeks ahead of time.
3. One bird per group will be led to the feeding ground, eyes closed. Upon opening their eyes, the birds will pick up the FIRST worm spotted with the clothes pin beak. Return to nest with the worm, and deposit it there.

RULES: Only one worm per flight can be picked up. Birds don't care what color worms are, so they must fly down and pick up the first one seen. No hovering, keep moving while searching for worms.

4. After each student has gathered two or three worms, it is time to stop feeding. Return to the classroom to count the worms by color, by making a data chart and graphing the result.

Performance assessment:

Ask students these questions:
What color worm was hardest to find? Why?
If you suddenly became a worm, what color would you want to be? Why?

What would have happened if the background was a different color?

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The Earthworm

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Objectives:

1. To acquaint students with earthworms
2. To help students to begin to overcome their fear of earthworms
3. To show students why they should have an appreciation for earthworms

Materials Needed:

Provide a sufficient amount according to the number of student groups
shoe box lids (for worm observation)
black cardboard for covers
tongs
magnifying glasses
flashlights
data sheets

Strategy:

Activity #1 Earthworm and Soil Fertilization

Each group will receive an earthworm for observation, and a checklist of necessary things to observe.

Color
Differentiation between head and rear end
Ears, eyes, nose, mouth, legs
How long is it?
How does it eat?
Describe the worm's appearance.
Where is the clitelum? What is it?
What does the earthworm smell like?
How does it feel?
Do you think that it has a brain?
Do you think that it has a heart? What color is the blood?
Do you have blood vessels?
Can you see them?

Discussion: How does the earthworm have influence on soil structure?

The ingestion of soil; the partial breakdown of organic matter; the mixture of these factions, and the ejection of this material as surface or sub-surface casts; the formation of water-stable aggregates; the aeration of the soil, and the improvement of its water-holding capacity; the addition of lime to the soil.

Activity #2 Miscellaneous Observations

Touch the worm in any spot. Put the worm in an open shoe box. Cover half of the box with a piece of cardboard. Put the worm in the uncovered portion of the box, and observe what happens. How does the worm respond to elevations? Does it prefer to crawl up or down?

Performance Assessment:

Did the students get used to the worms and handle them with confidence?
Did the students exhibit verbally or through their actions a respect for the earthworm as a complex living thing?
When the observations were completed, did most students show some concern about what would be done with the earthworms?

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The Amazing Starfish

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Objective:

The main objective of this mini-teach is to familiarize the students with the amazingly simple but complex characteristics of an Echinoderm. This lesson is geared towards students at the Jr. High-10th grade with slight modifications made as necessary. The lesson is intended to be taught with the assumption that several lessons have been covered on the Starfish.

Materials needed:

1. Preserved specimen of a Starfish
2. Modeling Clay
3. Straws
4. Rubber tubing

Strategy:

Paper is handed out to each student at the beginning of this mini-teach. They are given an opportunity to answer the question, "Are Starfish Simple or Complex?" This should take about 15 mins. The paper is handed in to the teacher. Students are given a brief review of what they learned in previous lessons. Teacher writes on the board the words: Sea Urchin, Sea Star, Sand Dollar, Sea Cumber. Students are asked the question, "What do these organisms have in common?" Students are to answer that these organisms belong to the Phylum Echinodermata. Students are also lectured on a brief review of the organ systems that are present in the Starfish. Special emphasis is placed on the Water Vascular System which is a vital component of some Echinoderms. This system is used for locomotion and food getting. Special emphasis is also placed on the body organization of Starfish. The definition of symmetry is given. Pentaradial symmetry is discussed because this is a type of symmetry that some Echinoderms exhibit.

Performance Assessment:

Students are to construct a figure with the modeling clay that resembles the components essential to the water vascular system. Step 1: Students take clay and make a round flat patty. (This is analogous to the ring canal that is present in Starfish.) Step 2: Students take 5 cut straw sections and place around clay patty. (This is analogous to the radial canals that are present in each arm of the starfish.) An explanation is given on how water enters the starfish and ultimately causes movement. Students assemble themselves in groups of five in a circle to illustrate the concept of pentaradial symmetry. Each student in the circle represents 1 of the 5 arms present in the Starfish. Paper is passed out. Students are now asked to answer the question once again, "Are Starfish simple or complex?" The paper is handed in to the teacher. The teacher evaluates the two answers noting if there is any change.

Multicultural Aspect:

American schools are a great mix of students from various cultures. Jacques Loeb was a German American physiologist who studied sea urchin eggs. He was particularly interested in the concept of parthenogenesis. Parthenogenesis is the reproduction of organism without the fusion of gametes of opposite sex. Explain what happens with bees.

Reference:

Encyclopedia of Marine Invertebrates. Jerry Walls, ed. 1982, TFH Publications Inc.

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A Guinea Pig Makes An Excellent Classroom Pet

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Objectives:

By carefully studying the behavior of a live guinea pig in a third-grade classroom for four days, the students will gain direct knowledge of the guinea pig's behavior and determine if it will make a good classroom pet.

Materials Needed:

guinea pig (live)	bread	insect
cage	corn	onion
observation guide questions	pellets	pepper
newspaper	apple	salt
carrot	banana	cloth
lettuce	meat	potato

Procedures and Strategies:

A brief outline of the subject to be studied will be presented by the classroom teacher.

The students will then be asked to observe and study the behavior of a live guinea pig in their classroom for four school days and write answers to the following questions based on their observations:

1. What does the animal look like?
2. How does it behave?
3. Does it like young children or does it become easily upset?
4. What foods does it like? Dislike?
5. Can it be trained? How?
6. What kind of noises does it make?
7. Is it safe to keep around children?
8. How often does it sleep during the day? How often does it play?
9. What are some basic rules we need to follow in taking care of the guinea pig in the classroom?

After the four-day observation period, a classroom discussion of the students' findings will take place on the fifth day.

Multicultural Emphasis:

Students will be asked to research the origin of the guinea pig and report their findings to the class for extra credit.

Performance Assessment:

Based on students' observations, study, classroom discussion and research, the students will write, in their own words, at least five reasons why a guinea pig will make a good classroom pet for third graders, and also identify the origin of the guinea pig (the country, the location of the country, and the language of the people who live there).

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Animal Behavior: "Groggy Goldfish"

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Objective:

To observe the behavior of goldfish in water of varying temperatures.

Materials:

Goldfish (4)
Fish Tank
Plastic Containers (4)
Thermometers (4)
Ice (large bag)
Timer or Wall Clock

Strategy:

1. Begin the lesson with a review of the definition of hibernation and cold and warm-blooded animals.
2. In groups of 4's, give each group one goldfish in a plastic container with room temperature water from fish tank, one thermometer, crushed ice and a chart.
3. Give each person in the group a job. (a timer, a counter, a reader, or a recorder)
4. Begin the investigation by taking the temperature reading and water operculum count of the control goldfish (20 seconds). Put findings on blackboard.
5. In group, take reading of the water temperature and a 20 second operculum count. Record on chart. (Remember to multiply by 3 to equal a minute).
6. Add a small amount of ice, wait 3 minutes, and take temperature of water and a 20 second operculum count. Observe and record.
7. Add another small amount of ice (use the same amount as used in step 6 above), wait 3 minutes and record the temperature. Take a 20 second operculum count and record on chart. Observe.
8. Continue adding ice in small amounts, recording temperature every 3 minutes until operculum is 0. Observe.
9. When operculum count hits zero, place goldfish in a warmer place and observe reaction. Remove any remaining ice and add some room temperature water. Observe.

Performance Assessment:

Students should be able to take accurate readings of the temperature of water. After a discussion of hibernation, students will predict what will happen to the operculum counts when the temperature of water is lowered. Throughout the investigation students will communicate, observe, measure, interpret, and record data correctly. Students will also write a brief description of what was observed during the investigation.

Multicultural Aspect:

Many kinds of fish live all over the world. They live in all climates on land and at all levels of the ocean. These fish develop bodies and ways of life that suit their particular region. People of all cultures use, observe, and enjoy many kinds of fish.

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What Can You Learn From A Mealworm?

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Objective:

To practice collecting metric data using mealworms.

Materials needed:

A Balance, 5x7 index card, mealworms, 2 rulers and graph paper.

Strategy:

Begin the lesson by discussing the metric system. It is a decimal system scaled on the powers of 10. Pick up a metric ruler and look carefully at the scale. You will see many little lines and every so often a much longer line marked with a number. The longer lines are centimeter (cm) marks and the shorter lines are one tenth of a centimeter (0.1) or millimeter marks.

Answer the following questions:
1. Using your metric ruler, draw a line that is 8 centimeters long. Put a small mark on the line for each centimeter length.
2. Draw a line that is 8 millimeters long.
3. What do you notice about the relationship between the lengths of these lines?
4. Measure the length of the following line: ___________.
   length = _______mm and length = ________cm.

After the students understand how to determine metric units, have them measure the length of the mealworm (anterior to posterior) in cm. Using a balance, weigh the worm. Record the data in table form on the blackboard.

Example: Name Length Weight Race I Race II Race III Avg.

Set up a racing card in the following manner:
A. Construct a track 1 cm. wide and 10 cm. long in the center of the 5x7 card.
B. Place two rulers on either side of the track to restrict movement of the mealworm.
C. Record the time it takes the worm to reach the finish line at the end of the track. Race the worms three times and then determine the average time. RECORD THE TIME IN SECONDS!
D. Record your results on the blackboard.
E. Using the data collected, graph the weight of the mealworms and the timings of the mealworms.

Questions:

A. What are mealworms? Where are they found?
B. Which worm was the fastest? Slowest?
C. Was there a relationship between weight or length and speed?
D. What is the difference between a spider and an insect?

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Animal Life Histories Derived From Morphology

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Objective:

These objectives apply to intermediate level students, specifically 6th grade.

Students will begin to learn the mechanisms of natural selection by deducing information from the physical appearance of the animal.

The format will help to develop reasoning skills.

Students will learn and use information concerning adaptation and habitats.

The class will gain experience in the formation of theories.

Materials needed:

Hand-out sheet showing the earth's biomes.

Hand-out sheet showing various examples of hares and rabbits.

Three exhibit cases from the Field Museum.

Strategy:

Students were introduced to the variety of the earth's biomes, i.e. tundra, taiga, deciduous forest, grassland, desert, rain forest, fresh water and salt water. These areas form habitats wherein can be found animals and plants which have survived because they possess qualities which enable them to adapt to that specific area. As an example, the students are told about a fictitious former student who always preferred to sit in the back of the room even though he had poor vision. The student would have to adapt to his situation by obtaining glasses or fail (not survive).

Students then receive the hand-out concerning the rabbit and hare. We discuss the variety of the animals and differences they show and their habitats, e.g. rabbits with the longest ears are found in desert regions; heat loss controlled through the ears. We focus on the snow-shoe rabbit in order to discuss the useful adaptation that provides the animal with a white coat during the winter. The class then proceeds to make judgments about the animal's food on the basis of the dentition. This leads to a determination of whether the animal is a predator or prey. As the latter, is decided students next theorize as to the rabbit's natural enemies and its ability to escape or defend itself from them. These hypotheses derive directly from the size and shape of the animal. In the last segment of this part of the lesson, the class will be shown the habitat box for the purpose of providing direct corroboration of their theories.

The second part of the lesson utilizes another habitat box from the Field Museum. Students are allowed to examine the animal which is placed in a natural setting. They are asked to describe this setting and name it in terms of the earth's biomes. Then the class begins to construct a natural history using the techniques shown above. Information is listed on the board as it is submitted by the students. At the end of this segment of the lesson students should have identified a habitat with possible alternatives, food, locomotion, characteristics, i.e. aggressive or passive, birthrate, adaptability. **No ideas are wrong, all are included in the list.**

For the concluding part of the lesson, the class will participate in a game which will also allow the instructor to evaluate student comprehension. The class will be allowed to ask four questions relative to where the animal lives, what it eats, type of dwelling, locomotion and then they will be asked to draw a simple schematic diagram of what they think the animal looks like using circles and ellipses. At this time the instructor may give his own "helpful hint" and then bring out the third of the habitat boxes. Students will be able to immediately reinforce or correct their judgments at this time.

Conclusions:

This lesson ideally provides the student with the opportunity to develop his reasoning skills while learning more about the life histories of animals which may not be very familiar to him. The approach is phenomenological since the actual animals are utilized. The students are not only involved in determining specific information they also get involved in using these techniques to hypothesize the shape of an undetermined animal in a game situation. Thus the approach moves away from the standard textbook situation to one wherein the student is actually using tools utilized by zoologists in the laboratory.

References:

Habitat boxes are available through the Field Museum. Call 922-9410 any week-day and ask for the Harris Extension.

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Marine Life: Whales

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Objective:

Grade Level six.

Students will fill in crossword puzzle utilizing vocabulary generated from the comparing and contrasting of common- and less common-place objects.

To prepare students for a visit to Shedd Aquarium.

Materials Needed:

An orange, sieve, chalkboard, picture file and school librarian.

Recommended Strategies:

Place the catagories "structure, function and behavior" on chalkboard.

Have students describe an orange.

Demonstrate the working of a sieve in order to convey the concept of the term "baleen". Record each characteristic under appropriate catagory. Follow with descriptions of the whale.

Compare and contrast characteristics of the whale and shark.

Give crossword puzzle to students.

Have students work in teams of three's. Specify one as the recorder and one the reader of clues--but all must contribute to solving the puzzle.

Solicit the help of the school librarian in providing as much material on whales as possible for student reference.

Provide pictures, charts and posters for visual clues.

Conclusions:

Students will complete a whale crossword puzzle as a group activity.

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Marine Life: Anatomy of a Humpback

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Objective:

Grade 3

To prepare students to visit Shedd Aquarium.
Students will assemble a picture of a Humpback whale on a grid.

Materials Needed:

Humpback whale puzzle
Humpback whale grid
scissors
glue
chalkboard--colored chalk
posters of whales

Recommended Strategies:

1. Outline the Humpback whale on chalkboard.
2. List the anatomical parts(to be read by students).
3. Have volunteers label and outline each part in different colors.
4. Distribute jigsaw puzzle and grid.
5. Children will cut out the puzzle pieces, match the letter/number key of the pieces with the letter/number coordinates of the grid, assemble whale pieces onto the grid and glue the pieces down to complete the picture.
6. Optional: Color the whale.
   Have students label parts on their whale.

Resources:

Shedd Aquarium gift shop has an excellent selection of books and posters on whales.
A drawing of a Humpback whale can be traced onto a transparency. Using the overhead, project this image onto the chalkboard. The image of the whale can be enlarged to desired size by moving the overhead either forward or backward. You can then outline the enlarged image onto the board.

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Classification of an Echinoderm

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Objective

To understand how the starfish relates to its classification.

Materials

Preserved Echinoderms, spiders, and other invertebrates and vertebrates.
Microscope projector. Overhead projector
Slides for production including the arthropods and echinoderms.
Illustrations of the starfish.
Animals with exoskeletons.
Chart with the family tree of living organisms.

Recommended Strategy

1. Students will observe the changes in forms, behavior, and feeding characteristics.
2. Ask the students, "Why can a starfish regenerate a missing arm?"
3. Students will be given an opportunity to observe the various parts of an echinoderm.
4. Discuss the historical background of a starfish.
5. Explain how the animal obtain its food.
6. Students will be ask to use the microscope to identify different structures of the organism.
7. Students will be asked, "Of what survival value is metamorphosis?". What is metamorphosis?
8. Students will be asked to explain how starfish reproduce.
9. After all students have identified the various parts of a starfish, they will compare the classification of the starfish with other invertebrates.
10. Students will show in which ways the echinoderms are similar to the chordates.

Activities

Students will give three characteristics of each animal, so they can identify the organism. All students will discuss the relationship between the arthropods and echinoderms.

Exercise 1:
Have students view how the echinoderms develop.

Exercise 2:
The students will dissect the dorsal side of the starfish to expose the internal structures.

Evaluation

Have students write an essay entitled: **How Invertebrates Live**. The students will observe the shift in body plan established in lower groups to bilateral symmetry in the larva stage to secondary radial symmetry in the adult stage. The students will compare these characteristics to the insects.

References

Laboratory Guide for the Biology Sciences, Modern Biology, and the Sciences of Biology.

If you want to see this experiment performed, you can come to Kennedy High School. Materials can be obtained at the American Science Center and the starfish, spider, and the centipedes can be obtained from Ward's catalog.

Summary

Insects are the most numerous group of animals on earth today. They have survived and flourished by combining a high reproductive rate with thousands of individual adaptations to different environments. The phylum Echinodermata consists of animals in which bilaterally symmetrical larvae undergo metamorphosis into adults with pentaradial symmetry. All echinoderms are marine.

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But, Why SEX?

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Objectives

1. To find the importance of sex in the study of continuity of life theme in biology.
2. To show the idea of sex offering genetic variability therefore allowing evolution to proceed at a faster rate when necessary.

Materials

Various sizes/colors of felt cloth - red, blue, yellow
Magnets (if chalk board is steel backed) and if NOT, then use pins, tacks, or strips of Velcro tape
Colored dittos - red and blue will do

Recommended Strategy

Ask students the description of the video Pacman game. Hopefully, they will mention monsters, pacman, power pills, maze, etc. Then develop a "biological" pacman maze by using a 3' by 3' piece of RED colored felt.

This felt becomes the background environment for the felt pacman shapes that can stick to it.

Then describe the two pacman types. Each pactype has two traits: eye and skin color. One pactype has red colored eyes and blue skin, the other has blue eye color and red skin.

Arbitrarily decide that blue eye will have superior vision compared to red eye. Superior referring to how they can see the power pills/monsters better than red eyes. Have the students explain why red skin is superior to blue skin color. The idea is that red skin is camouflaged by the RED (maze) environment.

Review, if necessary, the idea of genetic information being duplicated and the products of this duplication are allocated approximately to the daughter cells so that each receives only one copy of each message.

Activities

1. Have a yellow circle of felt as a nucleus placed within the pacman. Then have two felt chromosomes of different shapes and colors to represent the two traits and the alleles for that trait. Ask the students what would happen to the chromosomes, if to reproduce, the pacman will undergo binary fission. Use smaller felt pacmen for the daughter cells formed. Do this reproduction for both pactypes.

2. Ask what traits would "Super Pacman" have, and what process would allow two monoploid pactypes to produce an offspring with both beneficial characteristics, i.e., superior vision and camouflage in the environment. Point out importance of sexual reproduction in offering genetic variability.

3. Using colored ditto masters make an activity sheet that the student can mark in the traits, chromosomes, and offspring pactypes, for both asexual & sexual reproduction. However, this time have a BLUE maze environment, and let red eye be superior to blue eye.

(Note: in any of the above activities, students can come to the felt maze and move the pactypes and their offspring)

Reference

Article by A. Journet in Science Teacher, Oct' 84, page 50.

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Owl Pellets

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Objective

1. Discover and mount the contents of an owl pellet.
2. Relate the owls' eating habits with other animals (snake, cow, human).
3. Relate the contents of the owl pellet to the human skeletal system.
4. Discuss the food web, population control.

Materials (per lab group)

- owl pellets
- 3 dixie cups or beaker
- scissors
- hydrogen peroxide(optional)
- paper (white)
- water
- glue
- precut cardboard template
- bleach (diluted)
- various skeleton models
- metric ruler
- overhead projector
- forceps or toothpicks
- holepuncher
- handouts
  - a. bone sorting chart
  - b. skeletal mounting
  - c. bone identification
  - d. procedure
  - e. homework
  - f. key of skulls
- placemat (tray or paper)
- 1 liter bottle
- plastic owl

Procedure

Soak 1 liter bottle in hot water to remove label and base (this can be done at home). Cut bottle just below neck so that it fits snugly inverted in the base. Test cardboard for proper fit inside the bottle. Place owl pellet on the placemat. Gently separate bones from fur (soak in hydrogen peroxide for one minute if pellet is too dry). Place bones on bone sorting chart (make sure you have double of each bone, and one skull). Get teacher's approval. Soak bones in diluted bleach to clean and whiten the bones (soak only three minutes). Get skeleton layout sheet. Arrange bones on layout sheet. Get teacher's approval. Transfer bone layout onto cardboard. Get teacher's approval. Glue bones to cardboard. Use holepuncher to get circles for labeling of bones. Glue labels to cardboard near bones. Cut white paper to fit backside of cardboard (to be used as key for display). Make key for bone display using the bone identification handout. Glue key to cardboard. Place completed bone display into inverted 1 liter bottle which rests on the original bottle base. Hand in for grading.

Recommended Strategy

Begin the lesson by talking about the owl characteristics and its habits. Pass out the owl pellets and discuss the physical characteristics of the pellet. The students will be asked to measure their pellet and data will then be compared. Have the students gently pull apart the pellet. Students will share discovered contents from the owl pellet with the class, through a visual display on the overhead projector. By comparing the number and types of skulls found in each pellet the class will follow into a discussion on the food web and population control. The students will be able to identify their specimen by measuring and using the "key of skulls" handout. Continue the owl pellet project by following the above procedure.

NOTE: This project may take five to seven classes to complete.

SOURCES:
a. Mark Wagner, Kenwood Academy
b. Creative Dimensions
P.O.Box 1393
Bellingham, Washington 98227

OWL PELLET OBSERVATION

1. MEASURE THE OWL PELLET (IN MILLIMETERS)
   a.LENGTH OF THE PELLET ___________mm
   b.DIAMETER OF THE PELLET _________mm

2. IDENTIFY AT LEAST THREE PHYSICAL CHARACTERISTICS OF THE PELLETS - SMELL, COLOR, TEXTURE, ETC.
   1.
   2.
   3.

3. WHAT DO YOU THINK IS INSIDE OF THE PELLET?

4. IN WHICH PART OF THE OWL DOES THE PELLET FORM?

5. WHY DOES THIS PELLET FORM?

6. AFTER OPENING THE OWL PELLET WHAT INFORMATION WAS ATTAINED?

7. WRITE DOWN ONE QUESTION THAT YOU WOULD LIKE ANSWERED BY THE END OF THE OWL PROJECT.

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Animals and Their Coverings

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Objective

To review and recall information about invertebrates and vertebrates, cold-blooded and warm-blooded animals and their coverings.

Equipment and Materials

Pictures of animals with an answer sheet
Invertebrates and vertebrates (live, preserved or models, and coverings of animals such as scales, shells, feathers and fur)
Overhead projector with selected pictures of invertebrates and vertebrates to project

Recommended Strategies

1. Show a display of various animals and animal coverings allowing the students to observe as well as handle the material as they come into class.
2. Review cold-blooded and warm-blooded animals - what does cold-blooded mean? Have a student write the meaning on the board. Do the same for warm-blooded. Hold up a frog, a salamander, and a fish, while at the same time asking the class whether they are cold-blooded or warm-blooded. Discuss humans as warm-blooded animals. Re-read the definitions from the board.
3. Review invertebrates and vertebrates by tracing the backbones of skeletons of man, a frog, a snake, a giraffe, a bird, and a fish, while each of these objects is being projected on the overhead projector.
4. Show preserved animals such as crayfish, grasshopper, starfish; also pictures and/or skeleton of a horse, a polar bear, a snake or a giraffe. Have the students determine which of these animals are invertebtates and vertebrates.
5. Discuss animal coverings - have the students obtain animal coverings from the display. Ask: In what way does the animal use this particular covering? Of what is the animal covering made? (Suggested type of coverings - fur, feather, scale, smooth, spiny, hard or soft.)
6. Play a game using pictures of animals and answer sheets. Each station will have a picture of an animal, with a number on the back of each picture and an answer sheet. Students will have a time limit in which which to answer the questions, follow the directions and move to the next station.

Procedure: The leader explains the movement from station to station. Pupils will note the number, turn the picture over and answer letters A, B, C on the answer sheet. After 30 seconds the leader will call stop, the students place the picture face down and move to the right to the next station. At the signal to start the students begin answering the same questions for the next picture. This will continue until the students have completed all the pictures. Questions on each answer sheet for each number:

A. Is the animal cold-blooded or warm-blooded? Write C or W
B. Is the animal an invertebrate or a vertebrate? Write I or V

C. What is the type of body covering of the animal (fur, feather, scale, smooth, spiny, hard or soft)?

Use a transparency on the overhead projector to discuss the answers. After the students have corrected their answer sheets:

A. Search the answers to find and note the animals with fur and the animals with feathers.
B. Ask: Are any of these animals warm-blooded? What does warm-blooded mean? Anticipated answer: The body temperature stays more or less the same no matter how hot or cold the outside temperature.
C. Search the answer sheets and find all the invertebrates. Discuss: Are all of these animals warm-blooded or cold-blooded? Anticipated answer: all invertebrates are cold-blooded. Review the meaning of cold-blooded. Anticipated answer: cold-blooded animals take on the temperature of their environment.

Optional Activities

Do the following exercise using a 5 x 8 inch envelope made from cheesecloth and filled with feathers, a bucket of ice and your hands:

1. Hold the envelope with the feathers on your hand, and at the same time insert both into the bucket of ice. Note: be sure the feathers are between your hand and the ice!
2. Insert your hand in the ice bucket without the ice. Did the feathers keep your hand from getting cold? Discuss how the feathers of birds are used as insulation against the cold. Do the the same exercise using fur.

How do you think these types of coverings effect the body temperature of warm-blooded animals? Do warm-blooded animals need extra protection for cold weather?

Discuss: Animals grow extra thick fur in the winter and shed their fur in the summer. Birds molt or lose their feathers in the summer and fluff their feathers in the winter to keep their body temperature even. Humans wear layers of clothing in the winter to keep their body temperature even.

Resources

Magazines

Life Magazine, National Geographic, National Wildlife, International Wildlife, Outdoor Life, Scientific American, Smithsonian, Zoobooks, and Children and Science

Museums

Field Museum of Natural History, Harris Center - 922-94l0 Ex. 352
Chicago Academy of Sciences, Lincoln Park Zoo - 935-6700
Museum of Science and Industry, Shedd Aquarium - 939-2438
Chicago Public Library, Science/Tech. Info.-269-2865
American Science Center - preserved animal specimens -763-0313
Chicago Teachers Center - picture laminating -478-2506
The Learning Tree - 44l9 N. Ravenswood - charts on morphology of animals -769-3737

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Animal Behavior

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Objectives

1) Students will observe stimulus-response behavior.
2) Demonstrate the use of the scientific method.
3) To distinguish between learned behavior versus innate (inborn) behavior.

Equipment and Materials

Leeches	Flashlight
Crayfish	Beral Pipettes
Earthworms	Thermometer
Ice and Water	Batteries and Wire
Liver	Forceps
Sugar	Trays
Vinegar	Box and cardboard

Recommended Strategies

Demonstrate stimulus-response actions from your class by the firing of a toy cap gun. Discuss student reactions to the stimulus by questioning what has happened. Discuss stimulus-response in terms of human behavior. What types of behavior do humans have? What causes us to behave in a certain way? Are we all born with the same behavior? Distinguish between the types of behavior, learned and innate (inborn). List examples of each type, with the class submitting answers.

Concentration will be on the stimulus-response actions of lower animal forms. Introduce the leech and the crayfish to the class as the specimens for this activity.

Introduce the stimuli to be used for the activity. Liver, weak acid (vinegar), and sugar water will be used for chemical stimuli. Battery and wire will be used for slight electrical stimulus. Cardboard box and flashlight will be used to test light-darkness stimulus. Use a section of cardboard for gravity stimulus. Crushed ice, warm water, and a thermometer will be used for change in temperature stimulus.

Students will make up and perform their own strategies with the materials provided by using the scientific method. Review the scientific method.

A. Define the Problem- What is our task for today?
B. Collect Information- Where can we get info. on specimens?
C. Form Hypothesis- What do you think will happen?
D. Experimental Procedures- Be specific as possible and very careful.
E. Observe and Record Data- Be very specific.
F. Conclusions- What do you think happened?

Separate class into groups. Each group will have three students. From each group there will be a speaker, recorder, and materials taken. A particular stimulus will be assigned to each group. Review stimulus with each group and reiterate, we are concerned with stimulus-response actions.

Discussion of methods used and conclusions drawn by each group. Assignment will be handed in as a group activity. Cooperative groupwork is essential.

Groups will exchange assignments during next class period and perform their own strategies to a different stimulus while comparing with another group's strategies.

For homework, groups will makeup their own follow-up questions and answer them as a group.

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Classification of an invertebrate:Sponge

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Objectives:

To become familiar with primitive animals.

Materials:

A. Sample sponges-two authentic sponges, one synthetic sponge, a large rock, a rubber band, a fish-like tank container (one gallon).

B. A picture of a knight in armor.

C. Dissecting microscope, dissecting needles, scalpel or single edge razor blade, sponge; Grantia.

D.)Discovery Center-microprojector, spicules slides, a poster displaying the geological time periods, a plant, a horny sponge, loofah illustrating five types of sponges, a picture of a finger sponge & a jellyfish.

Recommended Strategy:

1. Show the students a model of a knight in armor.

2. Ask the students, "What did the knight in armor use to insulate his armor?" (expected response: sponge)

3. Show the students a synthetic sponge and an authentic one. Ask students which of the sponges were used to insulate the knight's armor (expected response: the authentic sponge). Inform the students that the synthetic sponge wasn't manufactured until 1936.

4. State some historical background about the sponge. Include various naturalist, zoologist & biologist points of view. Discuss the uses of sponges.

5. Show the students an authentic sponge. Ask the students, "What do you see?" (expected response: holes, pores). Explain to the students that these pores caused the biologist to assign the animal to the phylum Porifera (pore bearing).

6. Show the students a container filled with water. Insert a sponge attached to a rock by a rubber band. Ask the students, "Can the sponge move?" (expected response: No. It's sessile). Then ask,

"What does the rock represent?" (expected response: a substrate).

7. Ask the student how he/she thinks the sponge obtains its food. (expected response:water).

8. Activity 1:
Pass out a handout depicting how the sponge feeds.
Discuss the handout in detail. (Use an overhead projector to illustrate this activity.)

9. Activity 2:
Laboratory exercise. The lab consists of students viewing the sponge, Grantia, under a dissecting microscope. In addition, the student will answer eleven questions.

l0. Activity 3:
After the students have completed the laboratory exercise, instruct them to view six exhibits & answer the questions in the Discovery Center.

Evaluation:

Have the students compare the observable characteristics of a sponge to the jellyfish.

Students will write a short essay entitled **Why Study The Sponge?**

References:

Send a self- addressed stamped envelope to Carol Giles Box l392 Chgo, Il 60690

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The Acetate Animal Hunt

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Objective:

Students should be able to determine which variations (adaptations) would allow an organism to survive and reproduce in a certain environment.

Apparatus needed:

25 clear acetate discs
25 yellow acetate discs
25 red acetate discs
25 blue acetate discs
Discs should be about 1 cm in diameter.

Recommended strategy:

This activity uses acetate discs of different colors to determine which variations may help an organism to survive in a given environment.
Use the entire floor area of the classroom as a habitat for a population of acetate "animals." These "animals" are all of the same species. The variation in the color of the discs representing the "animals" is due to different genetic inheritance. The following are the genotypes for each "animal."

COLOR	GENOTYPE
clear	ccrr
red	ccRR
blue	CcRr
yellow	CCrr

Each individual in the class will act as a predator searching for food. The prey will be the acetate animals. They will be given 2 minutes to search the area for "food." Collect as many acetate animals as possible. When the time is up, reassemble and count the total number of acetate discs found by all members of the class. Chart your findings for each color disc. List number originally used, number found, number left on floor,and frequency of genes left. Students may prepare a bar graph indicating the frequency of color genes remaining in the acetate population. Determine gene frequency by dividing the total number of each color organism by the number of surviving organisms. Then multiply by 100 to find the percentage.

Evaluation:

1. Which animals were most difficult to find? Explain.
2. Explain which acetate animals were the most fit?
3. Which were the most poorly adapted? Why?
4. What will eventually happen to genes of the most poorly adapted animals?
5. As far as the predators (you) are concerned, which of you will live and which of you will die?
6. List several factors that make the predators better adapted for hunting.

Summary:

1. What does it mean for an organism to be adapted to its environment?
2. Explain the concept of "survival of the fittest."
3. Give the students several scenes in which they must determine which organisms within a population would most likely survive if their environment was to change. Have them explain why. Example: Imagine a population of species of giraffe living on an African plain for hundreds of years. Assume that the variation in this species is such that neck length ranges from short to very long. Most individuals have average-length necks, but some have short necks and some have very long necks. Assuming that this population of giraffes has been at genetic equilibrium for centuries, what would happen if another species, such as leaf-eating deer, entered the area? Would the species of giraffes change?

NOTE: This paper has been modified from the original by the SMILE Staff.

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Reconstructing A Fossil Pterosaur

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Objectives:

1. Reconstruct the skeleton of Scaphognathus crassirostis.
2. Make inferences about the mode of locomotion, feeding habits, and adaptations of Scaphognathus crassirostis.

Apparatus needed:

l. Scissors
2. Transparent tape
3. Metric ruler

Instructional strategy:

1. Introduce the Animal Kingdom-Birds, Evolution, Habitats, and characteristics Worksheet.
2. Discuss the Geologic Calendar Worksheet.
3. Discuss Early History, Paleozoic: Life Leaves the Sea. Pass out fossils showing stems.
4. Discuss Early History, Mesozoic: Mammals Emerge, Reptiles Reign:
   - Amphibian Modern Skeleton
   - Reptilian Modern Skeleton
   - Aves Modern Skeleton
   - Mammalian Modern Skeleton

Recommended strategy:

1. Phenomenological approach - pass out envelopes containing bones of Scaphognathus crassirostis.
2. Direct students to assemble the skeleton in twenty minutes.

Review Questions:

1. What is the main function of the bones that make up Scaphognathus crassirostis's little finger?
2. List three features of S. crassirostis's skeleton that the animal was adapted to flying.
3. The fossil of S. crassirostis was found in limestone that formed in a warm sea-water lagoon. What could you infer were the feeding habits and food of this animal?
4. S. crassirostis's wings were made of a delicate flap of skin. If this flap of skin tore, the animal could not fly. Use this information to explain how S. crassirostis might have had trouble competing with bird species living during the Mesozoic Era.
5. Explain how the protruding fingers of the middle of the wing might have been used to clutch the edges of the cliffs from which the Pterosaur glided.

6. Explain how once a scientist has reconstructed a skeleton, the scientists can use this and other information to infer the appearance and habitat of the animal, since such a picture or model is called a RESTORATION.

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How and Why Chameleons Change Colors

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Objectives:

Given a chameleon, the students will observe the color changes and explain the possible conditions that cause this reptile to change colors.

Given a chameleon, the students will discuss the biological factors that cause color changes.

Given a chameleon, the students will note the amount of time needed in order for changes in the pigmentary system to become apparent.

Apparatus needed:

4 chameleons
16 pieces of felt (4 pieces of beige, black, green, and yellow)
4 flashlights
4 crickets
4 plastic boxes
4 brown paper bags

Recommended strategy:

Divide the class into four groups. Remove each chameleon from a paper bag. Note the chameleon's color at this time. The students will place the chameleons on varying colors of cloth. Note each color change and time needed for this color change to take place. Next, each group will shine a flashlight on the chameleon. Again, note the color change and time needed for this change. Now, place each chameleon and a cricket in a plastic box. Watch for a color change and the time. The students should notice that all of these factors could cause a color change. However, the most influencing factor is light. Explain to the students that the chameleon's ability to change color is controlled by hormones. These hormones act on various pigments in the skin. Special cells called chromatophores in the skin allow the chameleon to change colors. You might also want to discuss the meaning of the words "pigments" and "chromatophores".

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Biology/Chemistry

Let It Grow

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Objective(s):

These activities are designed for students in grade three. Students will identify the parts of a corn seed and a bean seed and understand their functions. Students will identify the parts of the plants that they have grown and understand their functions. Students will be able to compare characteristics of monocots and dicots. Students will identify the parts of a perfect flower and understand the process of seed formation.

Materials:

Gallon size zip lock baggies (one per child), paper towels, nametags, corn seeds, bean seeds, spray water bottles, staplers, scotch tape, corn and any kind of bean seeds soaked in water for 24 hours, peanuts. newspaper, magnifying glasses, hand held microscopes (optional), gladiolas (one per child), straight pins, samples of tomato and bean plant cuttings showing the flower and the early developing fruit, straight pins.

Strategy:

The first activity will be done two weeks prior to the other activities. Each child will receive one large baggie, one paper towel, one nametag, two bean seeds and two corn seeds. Children will fit the paper towel into the baggie and then place the nametags at the top outside of the baggie. Then they will place four staples through the baggie evenly spaced about 1½ inches from the bottom , horizontal to the top of the baggie. Next they will place each of their four seeds inside the baggie on top of a staple. Then they will spray water into the baggies, wetting the paper towels and seeds. Most of the air will be pushed from the baggies and they will be sealed. They will be taped to the window and observed regarding the germination and growth of roots, stems and leaves for the next few weeks. A journal can be kept with pictures of daily growth and measurements can be recorded and graphed.

The second activity is as follows. The children will be given a piece of newspaper, a magnifying glass, and a soaked bean and kernal of corn. Peeling the seed coat from the bean seed they will observe the seed's two parts and find the embryo inside using the magnifying glasses. Removing the seed coat from the corn is more difficult, but children will observe that the corn seed does not split into two parts. The corn embryo will be located and the terms monocot and dicot will be introduced. Have children take apart a peanut and identify it as a monocot or dicot. Have the children examine the seedlings in their baggies and look for other differences between monocots and dicots, for example parallel and netted veins in leaves. Have them draw pictures of corn and bean seeds and corn and bean seedlings and label parts. Have children use hand held microscopes to examine seedlings to find root hairs and stomates and draw what they find.

The third activity is as follows. Children will observe tomato and bean plant cuttings with flowers and the beginnings of fruit formation present. Pollination and the basic parts of a flower involved in seed formation, and the functions of each will be discussed. E ach child will be given a gladiola or some other perfect flower and a straight pin. The children will first remove the sepal and the petals and look for pollen on the inside of the petals. The male parts (the stamens) will be removed next, noting the pollen on their tips. The female part (the pistil) will be identified and it's tip felt for stickiness or moisture. Using a straight pin, the ovary will be split open at the base of the pistil and the ovules located. All flower parts will be examined using magnifying glasses and hand held microscopes.

Performance Assessment:

Journaling, including student generated drawings and oral and written observations, will be evaluated. Specific parts to be assessed are seed, plant and flower parts and their functions.

Conclusions:

Students will understand reproduction in flowering plants and with this knowledge will be ready to compare and contrast them to non-flowering plants.

Biology/Chemistry

Which Sex is it?

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Objective(s):

This lesson is designed for freshman level biology, but it is easily adaptable for lower grades.

Students will be able to identify the parts of a flower.

Students will be able to distinguish between a perfect and imperfect flower.

Students will improve coordination and dexterity.

Materials:

Flowers (preferably ones with both male and female sex organs)

Tweezers

Paper

Scotch tape

Scalpel if desired

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Strategy:

This may be used as a culminating activity or as an introductory activity. Have students obtain a flower, tweezers, tape and scalpel if desired. Students will remove the parts of the flower (petal, sepal, stamen, pistil or carpel) and tape the parts to a sheet of paper. Students will then label each part and the parts of the stamen and the pistil or carpel.

Performance Assessment:

Students will turn in the paper they just finished taping and labeling. This assignment can be an easy and fast assessment.

Conclusions:

Students should, when complete, be able to identify the parts of a flower and tell whether or not the flower has both male and female sex organs (perfect) or just one sex organ (imperfect).

References:

Any freshman biology text will aid in identification of parts.

Biology/Chemistry

Fun Activities Using Seeds

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Objective(s):

This lesson is designed to teach second grade students that seeds come in different sizes, shapes and forms. The students will be able to identify the parts of a seed and their functions in germination.

Materials:

Activity One	Activity Two	Activity Three	Activity Four
Fresh fruits and	Lima, garbanzo,	dry pinto beans	seeds soaked in
Vegetables, handy	black, pinto,	wet pinto beans	water over night
wipes, paper	kidney beans	that have soaked	hand lens
Towels, Baggies,	black-eyed peas	in water over	magnifying glass
Construction paper	small stuffed animal	night, centimeter	paper
Scotch tape	balance scale	ruler, gram and	
Popsicle sticks	graph paper	ounce scale	

-

Strategy:

Activity One

Give student's pre-cut fruits and vegetables. Ask students to remove the seeds of the fruits and vegetables. Use Popsicle sticks to help remove and gather seeds. Put outer portions of fruits and vegetables in Baggies. (Save for compost). Tape the seeds to construction paper labeling the seeds by name. Discuss different sizes, and forms of seeds from fruits and vegetables.

Activity Two

Mix Lima, garbanzo, black, pinto, kidney beans and black-eyed peas together. Give student a portion of the mixture. Ask students to sort the beans noticing their sizes, shapes and colors. Pass around a small stuffed animal. Ask students to guess how many lima beans would weight the same amount as the stuffed animal. Record their estimate for lima beans. Do the same (ask how many beans would weigh the same as the stuffed animal) for all of the beans and record their estimates. Use balance scale to determine the number of beans of each variety that equal the weight of the stuffed animal.

Record the actual amounts and make a graph with data.

Activity Three

Give students dry pinto beans and pinto beans that have been soaked over night. Ask students to weigh and measure dry and wet beans. Compare size and shape of wet and dry beans.

Activity Four

Give students pinto beans that have been soaked over night. Ask students to remove seed coat and open the seed. Use hand lens or magnifying glass to identify the little plant (embryo) inside of the seed. Discuss the parts of a seed and their function. Draw and label the seed and its parts including seed coat, food storage, little plant (embryo).

Performance Assessment:

Rate performance on a scale of one to four according to level of participation (rubric).

Level one -- inattention. Student was off task. Student cannot answer questions about seeds.

Level two -- attention. Student stayed on task. Students can answer "key" questions:" Do all seeds look alike? What are the parts of a seed? How are the parts used when the seed sprouts (germinates)?

Level three -- good attention. The student stayed on task and asks questions about the activities and topic. The student can answer "key" questions.

Level four -- excellent attention. They student stayed on task and asked questions and suggested other activities and ideas about seeds. The student can answer key questions and give statement describing the sequence of a seed sprouting (germinating).

Conclusions:

In activity one, the students removed seeds from a variety of fresh fruits and vegetables and taped those seeds to construction paper. The students discussed different sizes, forms and colors of seeds.

In activity two the students sorted different kinds of bean seeds and compared their weights to a stuffed animal. In activity three the students compared, weighed and measured wet and dry pinto beans. In activity four the students observed the parts of seed using a hand lens and named the part of a seed discussing the sequence of sprouting (germination) and the function of the parts in sprouting.

References:

Worksheets available from AIMS Education Foundation 1993

Biology/Chemistry

Data-gathering Activities Relating to Trees in Their Environment

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Objective(s):

Upper grade elementary students will be able to determine heights of trees and their ages. A canopy map will indicate optimal growing areas for the tree.

Materials Needed:

measuring tape, pencils, quadrant (bolt, string, cardboard)

Strategy:

The quadrant consists of a cardboard rectangle large enough to copy 90 degrees from a standard protractor and provide room for a rolled-up siting tube. When the student can line up the top of the tree through the siting tube while maintaining a 45^{O} angle, his distance from the tree is equal to the height of the tree. A less accurate but simpler method for determining tree height is to move back from a tree holding out a pencil until the tree is congruent with the pencil-making sure that the base of the pencil remains on the base of the tree-allow the top of the pencil to drop until the student can line it up with some object on the ground. A companion can then pace out the distance from the tree to the object sighted and thus determine the approximate tree height.

The age of the tree can be approximated by using the measuring tape to obtain the girth of the trunk at a point five feet above the base of the tree. This number is basically the age of the tree but bear in mind that this method does not work on saplings. Where possible the use of the tree-ring method on a cut tree could provide verification for the accuracy of this activity

Students should realize that the tree canopy does not radiate equally from the trunk of the tree. This can be demonstrated by making a map of the canopy. Students will select a tree, locate the eight cardinal points, and then proceed to pace out from the trunk in the eight directions until they are beneath the edge of the tree. This data will serve to allow the student to graph the entire canopy and show its relation to the trunk. Once the canopy has been diagrammed the student should enter into the data any external factors which may contribute to the characteristics he/she has plotted. These factors may be position of the sun or the location of other trees.

Performance Assessment:

Each team will collect data relative to their particular tree. By itself this information is relatively meaningless. But at the end of the individual information gathering stage the teams will submit their data to the instructor who will have designed a question for which analysis of the data will provide an answer. This answer will be provided by the team in the form of a short paragraph which develops their analysis of the data.

References:

Chinery, Michael The Complete Amateur Naturalist. Bloomsbury Books, London.

Investigating the Structure of the Flower

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Objectives:

The student will learn the basic anatomy of a flower by means of creating a model.
The student will understand the proportional relationships of the various parts illustrated.
The student will understand the value of modeling for learning purposes.

Materials Needed:

Two sticks of clay
Toothpicks
Two sheets of construction paper-red and green

Strategy:

Though flowers come in many varieties there are types that have both male and female sex organs on the same flower. These types are called perfect flowers. We can construct a model of a perfect flower with the above-mentioned materials. We start with a stick of clay which we use to fashion the stem. The stem will need to support the flower itself and will therefore need to be strong enough to support the structure. So don't stint on the amount of clay, use the entire stick to make the stem. Once done we need to cut out the sepals from the green paper. The sepals were the bud cover while the flower was developing. When the flower opened the sepals are pushed back and begin to shrink since they no longer function as part of the living flower. The sepals should be no larger than one-fourth the size that the petals will be for your model. Start by drawing a circle the size of the stem, this will be cut-out later. Around this circle draw a four-pointed star. This forms the sepals and when the circle is cut out it will fit over the top of the clay stem. Push the sepals down about one-half inch on the stem.

Now cut out from the red sheet the figure which will represent the petals of your flower. Again, as mentioned above, the petals need to be larger than the sepals. The ratio should be about 4 to 1. The petals serve as a type of container for the sexual organs of the plant, attractant of insects, and landing strip for the insects. The number of petals is specific for each floral genus so you are free to decide how many petals you want. As in the case of the sepals you must start with a circle the size of the stem. Once the petals are cut out, followed by the circle, fit them over the stem so that they rest on top of the sepals leaving a knob of clay.

The knob of clay will serve as a platform for the structures that we will now fashion. These structures are the stamen and the pistil. Beginning with the latter we will knead the clay into a shape that resembles a bowling pin. Since we are emphasizing these features they may be slightly exaggerated in size. Thus the pistil may be the size of your petals. The shape of the pistil is a case of form following function. The top portion of the structure is a landing platform for pollen. The enlarged base contains the ovules that sperm from the pollen will eventually fertilize.

Since nature usually prefers to avoid self-pollination the next structure, the stamen, should be modeled smaller in size than the pistil. It consists of the anther, which is the production site of the pollen, and its support, the filament. The latter is made with a toothpick, though for large-scaled models a drinking straw may be used. The anther should be a third to half the size of the filament. Its shape is much like an elongated kidney bean. The stamen should be grouped around the pistil, a suggested number could be six.

Performance Assessment:

Any type of modeling activity requires a high degree of concentration and a considerable return on the effort is a reasonable expectation. Consequently students can be tested on their acquired knowledge by having them make a drawing of a flower based entirely on memory. The drawing should be correctly labelled. One might give a possible number of five quality points based on their drawing and nine points for the flower parts for a total of fourteen points.

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Transportation in Plants

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Objectives:

This lesson is designed for middle school and high school. The objectives for this lesson are as follows: 1) Students will understand how the forces of adhesion and cohesion and the process of transpiration aid in the transportation of water through the plant. 2) Students will recognize the form and function of stomata.

Materials:

Glass tube (hollow; the smaller the diameter, the better)
Celery Stalks (with leaves; about 10 stalks for every 25 students)
Microscopes, slides, and cover-slips
Food coloring
2 glass containers
Scalpel
Scotch tape
Clear nail polish
Leaves from plants

Strategy:

1) preparation: mix several drops of blue food coloring with water in the glass container. Place the celery stalks in the container 4 days prior to the date the class will be using the celery. After mixing food coloring and water in the second container, insert the glass tube (the water should creep up the tube, but will not reach the top.) Collect leaf samples from around the campus.

2) the lesson:
PART 1: Have the students observe the water in the tube. Ask them why the water is creeping up the glass rod, apparently defying gravity. After discussing how the forces of adhesion and cohesion are responsible for the ascending water, have them compare the celery and the glass tube in terms of how high the water ascended. Students should notice that the water in the celery has risen to the tips of the leaves, while the water in the glass tube is much lower. Then pose the following question: "Why did the water rise so high in the leaves but not in the glass tube?" Following their responses, explain the Adhesion/cohesion/transpiration theory (include how the gradient of water potential moves water from cell to cell to cell to stomata.) Have the students view a thin cross section of celery under the microscope to discover the location of the xylem cells which are stained blue.

PART 2: Paint a small section of the underside of a leaf with clear nail polish. Let it dry completely. When dry, peel the polish off the leaf by pressing scotch tape to it. If done carefully, the polish should stay attached to the tape as you peel it away from the leaf. Affix the tape to a slide and search for the imprint of stomata in the polish (practice this method ahead of time). Once the students can recognize stomata, have them compare how many stomata are located on the underside of the leaf versus the top of the leaf. Relate their findings to solar radiation, transpiration, and the cuticle.

Performance Assessment:

To assess the student's comprehension of the lesson the following quiz would be administered:

1. Explain in detail how the forces of adhesion and cohesion and the process of transpiration aid in the transportation of water through the plant.

2. Predict what would happen to a plant if all of it's stomata became plugged by a substance that prevented the passage of matter into and out of the leaves. Provide an explanation for your prediction.

This quiz would be worth 6 points. The following rubric would be used for awarding points: Question #1 is worth 4 points with 1 point awarded for each of the explanations of adhesion, cohesion, and transpiration. The final point would be awarded for an overall coherent answer. Question #2 is worth 2 points, with 1 point awarded for a reasonable prediction and 1 point for an accurate explanation.

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Structure Of A Plant

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Objectives:

To Investigate How Plants Grow With And Without Seeds. Use scientific methods to perform simple experiments, including asking a question, making predictions, describing a procedure, making observations, collecting data, and drawing conclusions. Follow directions to complete a simple experiment. Gather, report, and compare data from simple experiments. Devise an experiment to measure plant growth. Test the factors that affect seed germination. Compare seed germination of several kinds of seeds. Observe the directional nature of plant growth. Compare and contrast questions that can be answered by doing experiments. Describe why similar investigations should produce the same results. Relate the results of observation. Organize observations and measurements into charts and graphs. Describe the type of data that can be collected from a simple experiment. Use a metric ruler to chart the height of growing plants. Add and subtract numbers, including decimals through the thousands, and thousandths place. Report the results of experiments in which the scientific method was followed. Investigate and identify the requirements for seeds to germinate. This lesson can be modified to teach grades kindergarten through eighth grade.

Materials Needed:

Flowers, enough for each student to have three
Beans, use a variety of different kinds
Ruler, one for each child
Plastic container, two for each student
Plastic zipper bag
Paper towel
Stapler and staples
Water
Scissors
Tape
Marker
Pen
Index cards
Dye or food coloring
Scapula
Hand lens
Straight pins

Strategy:

I will introduce a series of seven experiments regarding the structure of a plant. These experiments will be taught and studied at separate sessions. The students will investigate each step in the structure of how a plant grows.

The first experiment will consist of demonstrating how a seed is formed. In order to do this experiment you will need two kinds of flowers. One with the male and female reproductive organs and one with the female reproductive organs only. The teacher and students will observe the pistil (ovary) of the plant, and the stamen (pollen producing part of the plant). Flowering plants can have perfect or imperfect flowers. A flower that has both stamens and pistils is known as a perfect flower. For example, lilies, daisies, peach trees, and elm trees have perfect flowers. But in some species the flowers are imperfect. An imperfect flower is one that has either stamens or pistils, but not both.

The second experiment will demonstrate how nutrients are carried by water to all parts of the plant. To do this experiment you will need food color, water, a flower, a clear cup and scissors. Place food coloring in a cup half full of water, and place the flower in the water. It will show the veins in the flower in the color of the dye that was used, especially if a white carnation is used. We discovered how a stem carries water and minerals back and forth from the roots to the leaves.

The third experiment demonstrated what is inside a seed. We dissected a dry bean and a wet bean to find out what the differences were in the embryos of the seeds. We split the beans in half and compared the sizes of the embryos. In a handout we labeled the bean parts.

The fourth experiment introduced how scientist use the scientific method to collect data of an experiment. We did an experiment to compare the growth rate of beans that were soaked overnight to some that weren't. We planted some beans in a botany bag that had been soaked overnight, and planted some in a different bag that were dry. We recorded data of the growth rate of each botany experiment, by measuring information and graphing our results on an index card. For this experiment you will need two zippered plastic bags, paper towel, beans or other seeds, stapler and staples, water, scissors, ruler, and tape. Students should record the progress of growth of their projects. They can keep their records on index cards and place the cards directly under their botany bags. The botany bags should be taped to the window, or as near to the window as possible for best results.

The fifth experiment consisted of taking our plants out of the bag and dissecting the root of one of them. We observed the root under a microscope to see if we could detect the kind of cell growth that had caused the plant to grow. What we were looking for was meiosis to take place, that's when cells divide to make more cells. They undergo ordinary cell division to produce multicellular, haploid organisms. Certain cells of these haploid organisms later become gametes, and fuse to form a zygote. As you may know, in both plants and animals one of each pair of chromosomes in the diploid zygote is inherited from each parent.

In the sixth experiment we took another plant that we had grown and drew all of its parts on a sheet of construction paper. Have the students choose a plant that has complete growth. Such as, a plant with leaf growth, stem growth and plenty of root growth. Make sure they label their pictures and color them.

The seventh and final experiment consisted of planting their plants. For this experiment you will need two containers of dirt, small cardboard labels, straws and scissors. Have the students plant their plants in the pots. Label each container, one for the dry seeds, and the other for the seeds soaked overnight. Make sure that they put their plants in the right container. Have them use their labels to identify their plants. The straws should be slit at the top with scissors and labels inserted. Then the labels should be inserted in the dirt next to their individual plants.

Introduce some background information according to the grade level of the students. Scientist have found that during photosynthesis houseplants can clean polluted air. Through stomates, plants take in not only carbon dioxide but also carbon monoxide, formaldehyde, and benzene. Tested plants that were best at filtering contaminants are philodendron, golden pothos, and spiderplants. Houseplants may someday serve as air-filtering systems in space stations. Plants require water, nutrients, proper temperature and sunlight to grow. Define some scientific terms before carrying out each experiment according to the grade level and teacher discretion.

Performance Assessment:

The assessment is based on the outcome of the students science project. The assessment is also based on the care and observation technique that the student demonstrates on the behalf of the plant. The student should also have kept a journal of the day to day growth of their plants.

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Structure of Seeds and Effects of Fertilizer on Plant Growth

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Objectives:

There are two main objectives of this Mini-teach. The first is to learn about the structural components of seeds of higher plants and the functions of each of these components. The second is to investigate how fertilizer affects the growth of plants, particularly of seedlings, and how this relates to seed structure. An additional objective is to learn to express and interpret data/results using graphs. This lesson is fine for grade levels 3-8, with the level of sophistication (particularly regarding the data analysis) scaled appropriately.

Materials Needed:

Each student will need 10 2 inch (5 cm) pots, enough vermiculite to fill the pots, several peanuts (preferably raw) and 12 or so (dry) lima beans (other beans will also work). For the class, there will also be a need for enough flats to hold the pots, 10 or more one-gallon plastic jugs, a source of distilled water, a box of dry fertilizer (such as Miracle Grow), and razor blades (only for dissection of lima beans, if this is desired, and obviously only for older students). A space near a window in the classroom large enough for the flats is also needed, and magnifying glasses are a help.

Strategy:

First Activity: Investigation of Seed Structure

This activity works particularly well with raw peanut seeds, but can also be done with lima beans or other types of beans. If you use peanut seeds, each student should shell a peanut and remove the feathery coat on each seed. The seed (or peanut) can be seen to have two halves, demarcated by a longitudinal line all around the seed. Each student should hold the peanut using both hands and gently push the two halves apart at this longitudinal line. The peanut can then be observed with the naked eye, or with the aid of a magnifying glass. If the peanut has been separated successfully, there will be two similarly sized pieces; these are the "cotyledons" (there are two cotyledons in the seeds of "dicot" plants like peanuts and beans; other plants ("monocots") have seeds with only one cotyledon).

One cotyledon will have, at one end, a small structure that looks like a tiny plant. In fact, it is a tiny plant (actually a plant embryo). Close examination of the embryo will reveal that it has both leaves and a root. In the seed the embryo is in a quiescent state until the seed germinates, at which time it begins to grow. Until it grows large enough to manufacture its own food via photosynthesis, the plant depends on food stored in the cotyledons; the initial growth of the seedling thus depends on the food stored in the cotyledon(s).

The same activity can been done with dry beans, although the cotyledons will have to be pried apart with a razor blade. Alternatively, the beans (e.g., lima beans) can be soaked overnight in water, at which time the seed coat will slip easily from the seed and the cotyledons will separate easily without need of a razor blade.

Second Activity: Effects of Fertilizer on Seedling Growth

Each student should take ten pots and fill each with vermiculite. It is important to use a non-nutritive support (i.e., vermiculite) rather than potting soil, as potting soil has lots of nutrients, which will serve to complicate interpretation of the results. In other words, we want to control the amount of nutrients each plant will get and know what this amount is. A single dry lima bean should then be planted into each pot.

Each student (or group of students) should then prepare fertilizer solutions for the experiment. Into each of 5 one-gallon jugs, place one gallon of distilled water. Leave one of the jugs with water only (i.e., do **not** add any fertilizer to it). To the second jug, add the amount of dry fertilizer recommended on the fertilizer box for one gallon of water; mix/dissolve (this will be "full-strength" fertilizer). To the third jug add **twice** the recommended amount of dry fertilizer, and mix/dissolve. To the fourth jug add **one-half** the recommended amount of dry fertilizer and mix/dissolve. To the fifth jug add **one-tenth** the recommended amount of dry fertilizer and mix/dissolve.

Each student will have two pots/seeds that will be watered throughout the course of the experiment with the contents of **one, and only one** of the five jugs described in the previous paragraph (e.g., there will be two pots watered with the water only, two pots watered with the one-tenth strength fertilizer only, etc.). **All** pots will be watered on **exactly** the same schedule and with **exactly** the same volume of liquid. This will ensure that every one of the ten pots will always get the same amount of water; only the amount of fertilizer that each gets (from none to double-strength) will vary (because of the varying concentration of fertilizer (from none to double-strength) in each of the five jugs). The first watering should occur just after the seeds are planted; subsequent waterings should be on an as need basis (i.e., when the vermiculite is dry).

Students should record their observations in notebooks. In particular, after the seeds have sprouted, they should measure the height of each plant (using a ruler). It is very important when recording data to note the date that those data were recorded (it is also very important to record the date of the initial planting).

Performance Assessment:

Regarding the second activity, all of the seedlings will grow initially to a certain point, because of the food stored in the cotyledons. Beyond this, growth is dependent on photosynthesis and nutrients absorbed by the plants' roots. The latter is, in turn, dependent on the concentration of fertilizer added to each plant.

Thus, we might expect that the seedlings watered with water only (no fertilizer added) will grow to a certain height and then stop growing, when the food in the cotyledons is exhausted. But if the water contains fertilizer, it should support additional growth.

The data (seedling height versus days since planting) should be plotted. Students should use the resulting graphs to help in interpreting the results of the experiment, particularly in a quantitative way (e.g., How long is growth supported by the cotyledons alone? What percentage of the growth with full-strength fertilizer is due to the food in the cotyledons? Is one-tenth strength fertilizer enough to support as much growth as full-strength fertilizer, and if not, at least some growth above that due to the cotyledons alone? Does double-strength fertilizer afford better growth than full-strength fertilizer? Does half-strength fertilizer result in as good growth as double-strength and full-strength fertilizer?, etc.).

It may also be helpful for the students to review the first activity as the second activity is progressing, i.e., to remember what the cotyledons and embryo look like in the seed before germination, compared to how the seedlings appear as they are growing.

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A Close Encounter of the Tree Kind

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Objectives:

These activities are designed for a 6-8th grade setting.
Students will learn how to estimate the heighth of a tree.
Students will learn that bark can be a distinguishing characteristic of trees.
Students will learn how to make a bark print.
Students will learn how to estimate the age of a tree.
Students will learn the respiration rates of trees.
Students will learn about turgor in the tree's internal transportation system and how it is affected by the sun.

Materials Needed:

A sheet of carbon paper
A large piece of art or construction paper
A ruler
Plastic baggies
A meter stick
Sections of string at least six feet in length
Masking tape

Strategy:

This is an outdoor activity that will allow your students to gather information in the same way that scientists do.
Select teams of students (three or four in each group).

First activity-Tree measurement

Each group to select a tree. One member will position themself next to the tree. Another will take the ruler and step forward or backward until the ruler exactly fills the heighth of the tree. With this accomplished the student with the ruler will move the top of the ruler from a vertical to a horizontal position making sure that the base of the ruler still sights at the base of the tree. In this position the student will sight down the other end of the ruler and identify some object in the same line as the tree. Once identified, a member of the team will go to that spot, then pace out the distance from that point to the tree. This is the heighth of the tree reduced to a horizontal linear measurement.

Second activity-Age estimation

Scientists estimate that mature trees grow at a rate of an inch a year. Students can select mature trees, measure them around with a tape measure or string with a meter stick, and then compute the average age. This activity will allow your students to add another piece of information in their description of a tree.

Third activity-Bark rubbing

Each species of tree has a distinctive bark. Students will be able to use this information to identify trees during the winter when there are no leaves. It is useful for students to see that while trees conform to a general image they are in particular quite different. Student teams will tape large sheets to a tree and then, using the carbon paper, will rub over the bark creating an image which reproduces the texture of the tree bark.

Fourth activity-Water loss

Each group to fasten a baggie on an individual leaf and leave it there for an hour. Placement of the leaf should involve experimentation some should be in the shade, others in the sunlight. After an hour the baggies should be collected and the water collected should be poured into a graduated cylinder.

Follow-up activity

Students will collect leaves and twigs from the tree. With all of the information collected the teams can now make a display providing all the information that they have collected.

Performance Assessment:

Students will have successfully mastered the activities in this exercise if they can do the following:

Describe the process used in measuring a tree.
Describe the theory behind age estimation.
Describe a theory for water loss difference in leaves on the shady side as opposed to the sunny side.

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Aztec Floating Gardens

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Objectives:

This lesson was created for students of all ages at the elementary level grades K-8. Students will be participating in a series of short experiments involving plants in order to discover ways to create a hydroponic garden. Aztec history will be explored to gain student interest and to set up the background for the analysis and creation of the "Floating Gardens".

Background Information:

The basis of this project is phenomena derived from Aztec history. The Aztec civilization thrived for three centuries and successfully grew a multitude of produce including pumpkin, squash, and corn. The amazing aspect is that their crops were underwater due to the fact that where they were located, Tenochtitlan (now known as Mexico City), was primarily wet, marshy land. In order to survive, the Aztecs had to create ingenious ways of producing crops in underwater conditions. The students, like the Aztecs, will be faced with the problem of recreating an underwater garden in the classroom.

Materials Needed:

-celery stalks (8 to 10 depending on class or group size)
-red or blue food coloring
-clear plastic cups
-1 lb bag of sand
-1 lb bag of potting soil
-seeds of various plants i.e. peas, Mexican sunflowers, beans, etc.
-ziploc baggies
-paper towels
-large, clear plastic containers (garden itself)
-10 carrot tops (sliced from carrots)
-10 sponges (artificial or real, although real will work best)
-white carnations (optional)
-steel or plastic mesh
-large square or rectangular tupperware containers

Time Constraints:

This unit, depending on class setup, will require one to six weeks.

Procedure:

Mini-experiment #1:

This first "mini-experiment" will introduce the concept of how plants acquire nutrients from the stem upward.

1. Add 8-10 drops of red or blue food coloring to water in a clear cup.
2. Place a celery stalk or white carnation inside the cup.

Within 20 minutes, students will observe that the dyed water has been transported upward within the stem and has been deposited at the leaf tips. If possible, have the students observe a cross-section of the celery (or flower) under a microscope and label all parts. The next day, the changes will be even more dramatic, the leaves having a vibrant, dyed color.

Mini-experiment #2:

This mini-experiment will dispel a common idea among students; that only the method of growing plants is with black soil and seeds.

1. In a small circular pan (the black bottoms of 2 liter bottles will also suffice) add 2 inches of sand.
2. Cut the tops off of several carrots and place them in the pan with sand.
3. Add a small amount of water to the pan, enough to make the sand damp.

Within a few days, the students will observe the carrots beginning to sprout. The carrot tops contain the necessary elements to grow into another carrot plant and can be transported at another time.

Mini-experiment #3:

This experiment will build upon the previous activities' concepts and continue to establish that plants can grow in various environments.

1. Soak a variety of beans in a pot for one evening (if this step is not completed, the seedlings will sprout, but will take a longer time).
2. Fold a paper towel into fourths and add enough water to dampen the towel throughout. Place the towel inside a ziploc baggie.
3. Place 8-10 beans inside the baggie on top of the folded towel.
4. Tape the baggies to the window.

In a few days, the students will observe many changes and should take detailed notes. Discuss the idea that inside each seedling lies "a baby plant" waiting to grow.

Mini-experiment #4:

The students should now be knowledgeable and ready to create their floating gardens. Working in groups, the students should make a list of materials needed for their gardens and then set out to obtain those materials on their own. However, depending on the age level, this may not be possible. In any case, the students may need a variety of materials with which to begin. Soil, sand, plastic containers, seeds, and plastic or wire mesh are the staples of this experiment. Allow the students to work with their groups to discuss and draw up plans for their gardens using previous experience and research.

1. Take the large, plastic tupperware containers (or similar containers), and have the students fill them almost completely with water.
2. Using different materials, the students should now construct their floating gardens based on the group's plans, ideas, and drawings.

It will be interesting to see the different combinations the students have created. Some will create gardens with sand bottoms, soil bottoms, or a mix of both. Other groups may make multi-level gardens with irrigation systems.

Performance Assessment:

Once the students have completed their gardens, they should present them to the class. Students are to explain how they built their gardens and why they think their gardens will enable plants to grow. Questions can then be presented to the groups to guide discussions and provide constructive criticism. Each student should then keep detailed notes of all activities and changes that occur within the gardens.

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How Plants Spice Up Our Lives

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Objectives:

This lesson is designed for the third grade but can be easily adapted to lower or higher grades. The objectives of this lesson are:

* Students will be able to label and identify parts of plants.
* Students will be able to identify spices obtained from plants.
* Students will be able to determine what part of a plant a spice comes from by using taste, touch, smell and sight.

Materials Needed:

Activity I
- Fresh or artificial flowers
- Construction paper in different colors
- Markers/pens/pencils
- Scissors
- Glue

Activity II
- Pencil/Pen
- Copies of puzzle for each student

Activity III
- Small styrofoam cups
- Potting soil
- Popsicle sticks or tongue depressors
- Seedling plants and/or plant seeds
- Rulers
- Newsprint paper for graphs
- Journal

Activity IV
- Small containers with lids preferably to hold a tablespoonful of various spices
- Assorted spices
- Paper
- Pencils/Pens

Activity V
- Pencils/Pens
- Paper
- Food items seasoned with various spices

Presentation:

Depending on the grade level, teacher will discuss various parts of a plant with class and their functions. For the primary level, I would stick basically with the roots, stem/bark, leaves, bud and flower which may produce fruit/seeds. Explain that the roots of the plant hold it firmly in place, preventing it from being washed away by the rains or blown away by strong winds. The roots are also responsible for drawing nutrients from the soil or water so the plant will be able to grow and thrive. The stem is a conduit that allows all the nourishment gathered by the roots to be distributed to other parts of the plant. The bark of a tree operates in much the same way in addition to serving as a protective covering. Buds are the part of the plant that envelope the undeveloped flower before it blossoms. Leaves are the green offshoots of the plant that are often dried and ground to make spices. The seeds are produced by the plant flower and can be ground or replanted to grow another plant. Bring an assortment of spices in, processed as well as in plant form, for children to examine. Popular plant spices to bring are:

1. garlic	2. cinnamon	3. nutmeg	4. mace	5. thyme
6. coriander	7. black pepper	8. bay leaves	9. mint	10. dill
11. vanilla	12. mustard	13. scallion	14. sage	15. fennel
16. rosemary	17.ginger	18. jalapeno		
19. red & green peppers		20. cocoa/chocolate		

Strategies:

Activity I

After dividing children into groups of 3 or 4, give each group a live or artificial plant. They will examine each part of the plant as teacher points out the various parts of the plant. Then students will use scissors to cut out leaves, stems, roots, etc. from colorful construction paper and glue pieces on news print to make their own plants. They will use markers to label the appropriate parts of each plant.

Activity II

Each student will get a puzzle (crossword, word search, fill-in-the-blanks) generated by teacher to complete during class lesson. Answers to puzzle will include spices and/or plant terminology discussed in class.

Activity III

Groups of 3 or 4 students will be given styrofoam cups to plant seeds and/or seedlings. The name of the plant will be written on a popsicle stick or comparable marker and stuck into the dirt after the plant is potted. Students will keep a record of plant growth by making a graph on newsprint paper and writing entries in a daily journal. Each group of children will calculate the growth/projected growth of their plants during allotted period designated by instructor. At end of period, have each group graph the maximum growth of their plants and compare data.

Activity IV

Students will go around to various stations in classroom which have containers holding spices. Each container is labeled A, B, C... or 1, 2, 3... and students must try to identify each by touch, sight, smell or taste. They will record their answers on a separate sheet. Students will also identify what part of the plant each spice comes from.

Activity V

Students will participate in a taste test in class to identify the spices contained in a variety of food products which could range from chocolate milk, and apple pie to rye bread.

Performance Assessment:

Children will be able to identify the parts of the plant, name spices obtained from plants and identify which part of the plant the spice comes from with an 80 percent accuracy. For a written test, students will be given a copy of a plant on a sheet of paper and will be required to label each part that was discussed during the lesson. Depending on how many spices are presented in class, children should be able to identify at least two spices that come from each plant section. Orally, children should be able to tell their favorite spice(s) and tell what foods they can be found in. Assign children to do a one-page research paper on a spice they are not familiar with. Have them use the library, the grocery story and adults as sources of information. Include in paper where plant grows, what part is made into a spice and what foods contain the spice.

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Plant Actions

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Part A-Photosynthesis
Objectives:

To define the term photosynthesis.
To practice iodine test for the presence of starch in leaves.
To compare the results of iodine test of two leaves one that has been exposed to sunlight and one that has not.

Materials needed:

CAUTION! This activity uses heat and requires safety training and **supervision**!

small dish iodine eye dropper plant sauce pan alcohol
beaker tweezers black plastic tape scissors

Strategy:

1. Tape plastic around some of the leaves of a geranium plant. Place the plant in a light place for two days. Then pick a wrapped leaf, and one is not wrapped.

2. Heat water in a sauce pan, warm alcohol in a beaker. Dip both leaves in hot water and then leave them in the alcohol. When the leaves are almost white, add iodine to them.

Results:

The leaf that was not wrapped turns a dark color, but the leaf that was wrapped remains the same. The fact that the wrapped leaf did not change color shows that it did not have any starch. The change in color in the unwrapped leaf indicates the presence of starch. The difference between the leaves is the exposure to sunlight. It goes to show that sunlight is necessary for the manufacture of plant food. This process in which plants use sunlight and other natural resources to make their food is called photosynthesis. The green color or pigment is called chlorophyll. The light is absorbed by the chlorophyll which also transfers the energy thus derived and in some brings about the photosynthetic reactions.

Part B-Water Transport
Objectives:

To show hands-on how water is transported through the stem to other parts of the plant.

Materials needed:

glasses food coloring fresh carnations or celery with leaves

Strategy:

Pour five to seven drops of food coloring to each glass then add some water to each glass. Trim the flowers or celery stem so that the tubes will be freshly open and not clogged. Split the stem of one of the flowers. Put the split stem goes into each of the two glasses that hold two different colors. Put the unsplit flower into one of the glasses with colored water. Leave flowers at room temperature for an hour so.

Results:

The flowers will slowly and gradually change color. The flowers in each glass change to the color of the food coloring in the glass. The flower with the split stem will change into two different colors, one each side of the flower. This process shows that the stem of a plant not only holds the plant or tree in an upright position, but it also helps in the transportation of foods and liquids from one part of the plant to other.

Performance Assessment:

Findings can be judged by the science journal entries, or by oral or written reports. These activities are PASS/FAIL only.

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How Buds on Trees Survive the Cold (and Related Mysteries)

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Objectives:

This science "mystery" was originally presented to second and third graders, but is probably appropriate for grades 2-6. The objectives are (1) to see how the delicate tissues of a tree bud are insulated so that they can survive the winter, (2) to learn how to determine the age of a branch/twig, and (3) to see how growth of branches can vary from year to year.

Materials Needed:

Several small branches/twigs, taken from, preferably, a horse chestnut (buckeye) tree in late Fall or Winter (after the leaves have all fallen).

razor blades (for younger children, to be used by teacher only)

hand lenses

Strategy:

This lesson makes a perfect "science mystery." One way to introduce it is to ask the children how they stay warm in the Winter (they stay inside and their houses are heated, they wear warm clothes, they sleep under blankets, etc.). Then you show a branch and focus on the "terminal buds" on that branch (the terminal buds are those at the **end** of each branch). You point out that the terminal bud contains a baby stem and baby leaves and remind them that these "babies" have to stay warm all Winter also. The mystery is, how can they stay warm without the advantages the children have? You might remind the children also how cold it has gotten outside that winter.

Then show the children the outside of the bud(s). Note that the buds are covered by a series of hard overlapping "bud scales." Then, using a razor blade, slice open one or more buds laterally (left to right) through their centers. Observe with the aid of the hand lenses (or with the naked eye if no lenses are available) and perhaps make a drawing of what is seen.

Things to notice in particular are the many layers of the bud scales on the outside of the bud, the "baby" (embryonic) shoot and leaves in the center of the bud (which might be a bit hard to see), and the "cottony" packing material which tightly surrounds the shoot/leaves underneath the layers of the bud scales. The answer to the mystery, then, is that the embryonic shoot and leaves are protected from the cold by both the layers of bud scales and the cottony material, and so are able to survive the Winter cold.

In the Spring, the embryonic shoot/leaves in each bud begin to grow. As they do, they shed the cottony material and the bud scales, which fall off the branch. Loss of the latter produces a series of bud scale scars at the base of the former bud; these look like a series of (mostly) parallel lines around the circumference of the branch. The position of each group of bud scale scars, then, permanently records the position of a terminal bud that had existed at one time in that position on that branch. The distance between adjacent bud scale scars on a branch represents the growth of that branch in one growing season (this might open a lively discussion by determining if the growth of a branch had been the same in each year and, if not, what variables--heat, rainfall, etc.--might have led to growth variations). The overall age of the branch can be determined by counting the number of groups of bud scale scars on it. Note that if your branch has smaller branches growing out of it, they will have to be younger than the main branch, and this should be confirmed by the bud scale patterns on each.

Performance Assessment:

Students could be graded on their diagrams of the dissected buds, with points given for accuracy, neatness, detail, and correct labelling. You could also ask students for a short written report covering such topics as the age of their branches (and how they determined them), if there was variable growth from year to year in the branch and how this was determined, etc.

References:

Probably any good high school or college general biology or botany text would be a useful resource for this activity.

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Structure and Function of Seeds

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Objectives:

Seeds of flowering plants have two main parts, the "cotyledon(s)" (one or two, depending on the seed type) and the "embryo" (a tiny "baby" plant in a state of suspended animation). When the seed is planted and begins to germinate, the embryo will "reawaken" and begin to grow and develop. Initially it uses resources stored in the cotyledon(s) for this purpose; when the growing plant gets a bit bigger, it is able to (and must) obtain minerals and water from the soil and carbon from the air on its own. In these exercises the structure of a seed (particularly the embryo) is observed and two experiments are performed to show the function of the cotyledons in providing nourishment to the plant during the early times after germination.

Materials Needed:

The following list is intended for a class of 25 students.
1. one bag of lima beans or raw peanuts (note: roasted peanuts will not suffice).
2. 150 paper cold drink cups (10 ounce or larger size)
3. 10 pounds of potting soil
4. one big bag of vermiculite
5. one box of miracle grow (dry) plant food
6. three one gallon plastic milk containers
7. hand lenses
8. razor blades or suitable substitute (choice adjusted for appropriate grade level)

Strategy:

1. Hand out one or two seeds to each child. For this part of the exercise peanuts work a bit better than lima beans, but both are suitable and work the same way. Separate the two cotyledons from each other by carefully inserting a razor blade or other sharp edge between the cotyledons and gently prying them apart (you will see a line in the seed which denotes the point of separation between the cotyledons). At the bottom of one of the two halves you will find the embryo. Close inspection of the embryo, particularly with the hand lens, will show that the seed does, in fact, carry a tiny version of the plant, including leaves and root. Also note the size and location of the cotyledons in relation to the embryo.

2. Plant one or two seeds (of one or both types as desired, each in a separate cup) into the potting soil. Water (with tap water) the pots as needed to keep the soil moist, but don't overwater them. Also, remember to water all pots exactly the same way (same days, same volume of water, etc.). Don't feed this set of plants with the plant food. After a few days the seeds will germinate. The first two oval shaped, leaf-like parts of the plant you will see are the cotyledons; the real leaves will appear later. Record data as follows:

1. Record date of planting.
2. Record watering schedule (days, volumes, etc.).
3. Record date that germinating plant is first visible.
4. At each date following emergence of the plant record both the diameters of the cotyledons and the overall height of the plants. If more than one plant is being measured, be sure to keep measurements for each plant individually.

3. Choose three seeds of the same type. Plant each in a separate cup filled with vermiculite, not potting soil. Fill the three gallon containers as follows:

1. One with just tap water.
2. One with miracle grow made up according to the directions on the box.
3. One with miracle grow made up to only one fourth of the strength listed on the box (e.g., if full strength miracle grow uses one teaspoon per gallon, use only one fourth of a teaspoon per gallon for this container, etc.).

One plant will be watered with water only, one with full strength miracle grow only, and one with one quarter strength miracle grow only. It is very important that each plant get watered only from one of the containers during the course of the experiment and also that all plants get the same volume of liquid on the same days. Watering should be done to keep the soil moist. Record the watering/feeding schedule for each plant, the date of emergence of each plant, and the height of the plant and diameter of the cotyledons at each date after emergence.

Performance Assessment/Conclusions:

I have done these exercises with fifth and sixth graders and even as a science fair experiment for a bright third grader, but they could probably be adapted for high schoolers as well. The data analysis can be more sophisticated as the kids get older, but all grades should be able to draw the seed and embryo as seen through the hand lens. All grades should be able to make a simple graph of the data, specifically height of the plants and cotyledon size versus time (it is useful to plot the height and cotyledon size versus time on the same set of axes). The older grades might do more sophisticated graphs such as (especially for experiment number 2 above) plotting the ratio of plant height to cotyledon diameter versus time. In addition, data from the entire class can be pooled; this allows for cases in which one of an individual student's plants didn't germinate and also allows for lessons in averages.

Things to discuss are the structure of the embryo and the cotyledons (experiment 1), how the sizes and relative sizes of the cotyledons and plants change with time (experiments 2 and 3), and whether giving the plants miracle grow enhances their growth and whether this enhancement occurs throughout the course of the experiment or only after a certain time (experiment 3). Implicit in these discussions is that the cotyledons supply the nourishment for plant growth for a time, but then the plant must get its nourishment on its own. How do the data from experiments 2 and 3 illustrate this? For example, in experiment 2 does the cotyledon size remain constant or shrink while the plant size keeps increasing? In experiment 3 do the three plants grow at the same rate for a while, but eventually do the fed plants grow faster, and does the plant with higher strength miracle grow do the best?

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Seed Germination

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Objective:

The main objective of the Mini-teach is to show students that water and air are essential to the germination process of plant life and that this process can be demonstrated by using any different number of growth chambers.

Materials Needed:

plastic bag	magic tape
stapler/staples	masking tape
paper towels	fresh-dry lima beans
plastic knives	water-soaked lima beans
clothes pins	

Strategy:

1. Make some physical observations of the soaked seeds and the dry seeds, but be sure you soak the seeds for observation at least 24 hours.
2. Discuss some of the variations when you cut open the soaked seed and when you try to cut open the dry seed.
3. Take a sheet of paper towel and fold it in half and take that half and fold it in half to make a perfect square.
4. Place dry seed on the paper towel securing it with a piece of magic tape.
5. Place a paper towel in a 7" X 8" zip lock plastic bag. Be sure to secure the paper towel inside the plastic bag using your stapler. Staple only the two top ends of the paper towel onto the plastic bag.
6. Moisten your paper towel thoroughly.
7. Place the bag in a warm spot such as against the window. Using a clothes pin, hang it up on a string of wire roped along the window with the seed facing outward toward the sun.
8. Examine the seed package and note how many days must pass before the seed germinates. On the day that the seed begins to germinate, remove the bag from its warm spot to see if the first small roots have broken through the seed coat. Wait three more days and change the position of the plastic bag by rotating the bag 90 degrees clockwise.
9. Examine the seed package and note if gravity has had any adverse effect on the directional change in the stem and root growth.
10. Don't try to save the seedling from the germination test because it will die after planting since its tiny, delicate root has been seriously damaged.
11. Keep this method in mind if your project calls for applying a chemical solution that may affect the speed of germination or if you have to measure root growth in the seedling.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. Why is air an important element for seed germination?
2. Why is water an important element for seed germination?
3. What happens to a water soaked seed?
4. Is the direction of the stem and/or root affected when the growth chamber is rotated?
5. Why can't a dry seed germinate?
6. How long can a dry seed survive while in its dormant state?
7. How long can a soaked seed survive while it is germinating?
8. Will the soaked seed germinate faster if exposed to sun light or artificial room light?
9. What is a growth chamber?
10. What will happen to a germinating seed if it is removed from its growth chamber?

Conclusion:

The students will understand that water, air, and sunlight are important to successful seed germination.

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The Structure of A Flower

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Objectives:

Observe the structure of a flower.
What function does each of these structures serve?
Observe the variety of flower shapes.
To identify the parts of a flower reproduction stage: pollination.

Materials needed:

gladiolus flower, forceps, hand lens, dropper, water, microscope slide, scalpel, coverslip and microscope.

Strategy:

Displayed an illustrative drawing of the structure of a flower on the chalkboard. Referring to the display; students and teacher labeled each part of the flower.

Students and teacher reassembled a disassembled artificial flower; labeled the parts as we reassembled the flower.

The class was given live flowers for dissecting. Some dissected parts were placed on diagrams of flowers.

Class members were informed that in flowering plants, it is the transfer of pollen from an anther to a stigma.
Most flowers are pollinated by insects. Some by animals, wind or birds.

Performance Assessment:

The assessment would give the result of the findings of parts of the flower. The live flower revealed more parts than did the artificial flowers, with the exception of the pistil.

Presently, students have become familiar with the basics of the flower.

Thank you!

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Birth of a Plant From a Seed

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Objectives:

Students shall be able to label parts of a dicotyledon seed by function as well as by proper names.

Materials needed:

2 each lima beans, and red kidney beans
1 hand lens
1 single edged razor OR scalpel
colored paper, pencils, crayons, scissors, glue
iodine, to test for starch (opt.)
envelopes containing "job" vocabulary as well as the proper name, as follows:
seed embryo, seed coat, food (cotyledons), root (radicle), stem and leaves (plumule), hylum, microphyle, internal landmarks, internal structures

Strategy:

Students will compare and contrast a dry bean versus a rehydrated bean, both lima and red kidney. 24 hours is needed to "fluff" the dried beans. Students can do this for themselves. CAUTION: DO NOT soak for more than 24 hours as the seed coats come off, and the likelihood of decomposition (rotting) is increased, with the growth of some quite interesting molds.

The external landmarks of the microphyle and hylum are easier to see on the dried bean, although the rehydrated beans will show the interior structures better as they will be larger.

Part 1: Students are to examine both dried beans, and locate the "bellybutton", hylum, of each, then scan carefully for the "dimple", microphyle. Drawing what has been described and observed can take place here, depending on time limitations and supplies.

Part 2: Have the students take all the vocabulary words out of the envelope, and separate them into columns of WORDS KNOWN and WORDS UNKNOWN. Further separate the KNOWNS into the EXTERNAL LANDMARKS and INTERNAL STRUCTURES. Place the known names on the drawing. Have students attempt pronunciation of new words. Offer crutches, such as plumule is for the stem and leaves, like a plume. This is also a good time to look at some of the roots, like micro-, meaning little. New words need to be mounted on the individual student drawings. Having the function name and the proper name paired will give a good study guide, incorporating the new and old knowledge.

Performance Assessment:

Words will be correctly paired on student drawings.

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Indoor Gardening

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Objectives:

To learn how different plants grow under certain conditions. To describe several uses of seed plants. The students will identify different seeds.
To plant the seeds and watch them grow. Watch for the seven requirements for growing plants indoors:

1. Room to grow
2. Temperature
3. Light
4. Water
5. Time
6. Air
7. Food

Materials:

Seeds, bulbs, potting soil, quart Ziploc sandwich bags, water, 2-liter bottles, scissors and decorations (optional). Mature plants, as examples are helpful also.

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Procedure:

1. Fill plastic bag 3/4 of the way with good moist soil (a pot may also be used).
2. Select seed.
3. Plant seed about 1/16 of an inch deep.
4. Water plant with light spray. Set in sunny window.
5. The students may draw the plants as they grow.
6. Measure the stem and root growth each day and graph.

Performance Assessment:

Students will be able to:

1. Understand that plants will grow only under certain conditions that are compatible to each species;
2. Identify different seeds;
3. Observe their indoor gardens's growth;
4. Name the seven requirements for growing plants indoors.

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Photosynthesis

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Objectives:

(Adaptable to grade levels 6-9)

The student will:
1. Observe evidence of photosynthesis in a water plant.
2. Assemble the equipment needed to measure the rate of photosynthesis in elodea (water plant).
3. Count bubbles of oxygen gas given off by elodea to determine the rate of photosynthesis.
4. Change the conditions of photosynthesis by altering light intensity and carbon dioxide amount, and determine the effects on the photosynthesis rate.
5. Prepare a graph of the collected data and analyze it.

Materials Needed:

(For each group of four students)

elodea (water plant)
test tube
dechlorinated water (room temperature)
sodium bicarbonate powder (baking soda)
metal stand with rod or test tube rack
lamp (40 watt)
razor blade (single-edge)
tape
clock or timer
metric ruler

Strategy:

PART A. Setting Up the Experiment
1. Obtain a sprig of elodea. Remove several leaves from around the cut end of the stem. Slice off a portion of the stem at an angle and lightly crush the cut end of the stem.
2. Place the plant into the test tube, stem end up, filled with water.
3. Secure the test tube to a metal stand with tape or place the test tube in a test tube rack.

PART B. Running the Experiment
1. Place a 40 watt lamp 5 cm from the plant. After one minute, count and record the number of oxygen bubbles rising from the cut end of the stem. Count bubbles for five minutes. If bubbles fail to appear, cut off more of the stem and recrush.
2. Run a second five-minute trial. Record and average your results.
3. Move the lamp so it is 20 cm from the plant. After one minute count and record bubbles for two five-minutes trials. Again, average and record your results.
4. Add a pinch of sodium bicarbonate powder to the test tube. Place the lamp 5 cm from the test tube. After one minute, record bubbles for two five-minute trials. Average and record your results.
5. Prepare a graph of your results. Use the average number of bubbles for the

vertical axis. Use the type of environmental condition for the horizontal axis.

Performance Assessment:

The students will answer these questions using specific values from the investigation. Diagrams may be included.

1. How does this investigation demonstrate that plants give off oxygen during photosynthesis? Explain your answer based on your observations.
2. How does the rate of photosynthesis change when the light source is moved from a distance of 5 cm to 20 cm?
3. How does the rate of photosynthesis change when sodium bicarbonate is added to the water?

Conclusions:

Plants use green pigments called chlorophylls to trap light energy. The chlorophylls give a plant its green color. Inside the cells that have chloroplasts, the light energy is used to make a simple sugar called glucose. The process by which plants use light energy to make glucose is called photosynthesis.

During this process of sugar production, carbon dioxide combines with water to form glucose and oxygen is released. Oxygen that is produced in photosynthesis is given off as a gas. If a lot of oxygen is being given off, photosynthesis is occurring rapidly. If little oxygen is being given off, photosynthesis is occurring slowly. The amount of trapped light energy and the amount of carbon dioxide available affects the rate of photosynthesis.

The purpose of adding sodium bicarbonate powder to the water increases the amount of carbon dioxide in the water.

This investigation can be performed with water plants grown in many parts of the world, except regions that have permanent ice.

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Tree Identification by the Use of Leaves

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Objectives:

1) Utilize the phenomenological approach to motivate students at the sixth grade level to understand how leaf arrangement and structure can be used for tree identification.
2) Develop the ability and desire to use concepts presented to identify all the trees included in the mini-teach plus the remaining ones in the neighborhood.

Materials needed:

1) Five motivating clue statements on posters
2) Two large sheets of construction paper for every two students
3) Four sheets of typing paper for each student
4) Six leaf samples from the local area for every two students
5) Prepared leaf drawings for performance assessment
6) Herbarium collection and leaf keys for display

Strategy:

1) The night or morning before the lesson, collect six different leaves from the local area for each pair of students. Press them between two folded sheets of construction paper and seal them with masking tape.
2) Divide the class into groups of two and give each pair a sealed set of leaves plus eight sheets of typing paper.
3) Display the five motivating clue statements which follow and have the students guess what is in each set.
   clue 1 One of us is believed to be the oldest and largest of all living things.
   clue 2 Some extinct species of us have been petrified.
   clue 3 Some of us have received names of famous people such as Abraham Lincoln and General Sherman.
   clue 4 Always use our multicultural scientific names, which are the same throughout the world, if you don't want to make a mistake naming us.
   clue 5 The part of us that manufactures food is squeezed between the papers on your desk. Name that part.
   Note: Clues 1, 2, and 3 refer to the coniferous giant sequoia tree, and the final answer for all five clues is LEAVES OF TREES.
4) Each pair of students who are sure of the answer should raise their hands and secretly give the answer to the teacher. Jelly candy leaves may be given as a reward.
5) When everyone knows that the enclosed objects are leaves the sets are opened and each leaf is sketched by each student.
   step 1 A sheet of typing paper is placed over each leaf one at a time.
   step 2 Students use their pencils and sketch over each leaf with an acute angle between the pencil and the paper so the side of the graphite is used. They must press hard to show entire leaf blades, margins, and petioles.
6) After the leaves are sketched, ask the students to observe and identify the

following:

Deciduous Trees

Margins (entire, serrate, lobed, toothed)

Venation (parallel, palmate, net)

Shapes (oval, linear, heart, fan, different shapes from the same tree)

Types (simple, compound, double compound)

Arrangement (alternate, opposite, whorled)

Evergreen Trees

Needlelike (Bundles of 2-5, clustered)

Scalelike

7) Show a leaf identification key to develop the concept of identification by the use of the above structures. Name the six leaves sketched.
8) Show other examples of leaves in the local area by using an herbarium collection or fresh samples.
9) Take the class on a walk around the school building or local area and identify trees by using the leaf structures and arrangements observed and discussed in class.
10) Introduce the importance of using scientific names. They are the same throughout the world. The same common names have been given to more than one plant and improper identification has occurred. **Asimina triloba** is deciduous and **Carica papaya** is evergreen, and both have been called paw-paw or pawpaw. The common name sycamore has also been given to completely different trees.
11) Assign students to write reports about trees which are native to an area or country representing their cultural heritage.

Performance Assessment:

1) Ask students to identify the trees studied on their walk when the same trees are observed again on the return trip.
2) Leaves sketched in class and observed during the walk should be labeled correctly in a station to station test conducted in the classroom. Place numbers on each sketch, fresh sample, or herbarium sheet, and tell the students to write the correct name for each leaf as they are held up or observed at a specific location.
3) Require students to define or draw two examples of different margins, venation, shapes, types, and arrangements.

References:

Petrides, George A., **A Field Guide to Trees and Shrubs.**

Zim, Herbert S., and Martin, Alexander, **Trees A Guide to Familiar American Trees.**

Elias, Thomas S., **The Complete Trees of North America Field Guide and Natural History.**

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Seeds-Seed Sort

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Objective:

The second grade students will count and sort seeds and find the likenesses and differences of many seeds.

Materials needed:

Small Dixie cups-one per group of 3-4 students: lima beans, kidney beans, pop corn, sunflower seeds, garbanzo beans, black-eyed peas, etc., magnifying lens, balance scale.

Strategy:

1.Students should be given background information about seeds:

Seeds are all different sizes and shapes and they come surrounded by all different kinds of fruit. But all seeds are alike in two ways. Every seed contains a little plant called an embryo. All seeds contain food that helps the little plant grow.

All seeds are remarkable in the way in which they spread themselves in order to grow new plants. Some seeds simply fall to the ground, others float on water, some are fired like buckshot over a distance, and others attach to an animal's fur.

All seeds serve the same purpose, to germinate and grow a new plant in order to perpetuate the plant species.

2. Provide an assortment of seeds. Mix the seeds together so the students can be given a representative sample.

3. Place the students in groups of 3-4 and give each group a small cupful of seeds.

4. Have the students estimate how many seeds are in the cup.

5. Give each group a copy of the worksheet "Seed Sort".

6. The students will dump the cup of seeds into the circle in the middle of the paper and sort the seeds into smaller sets of like kinds and put them in the smaller circles.

7. A record should be made of the name and number of seeds in each circle.

8. Then have the students add the smaller sets to get the total number of seeds in the cup.

9. Have students use a magnifying lens to look closely at the seeds. What color are they? Are there any that have two colors? The students can record their answers on the worksheet "Observing Seeds".

10. Ask the students: What are the shapes of the seeds? Have them record by drawing the shapes of the seeds in the shapes column.

11. Have the students guess how many seeds it will take to cover the line. Lay the seeds on the line, count them and record.

12. The students will use the worksheet "Comparing Seeds" to weigh the seeds. They should estimate how many seeds it will take to balance one gram and then weigh the seeds and record the results. At the bottom of the page record by coloring the graph.

Performance Assessment:

The performance assessment will be the completion of the worksheets "Seed Sort", "Observing Seeds", and "Comparing Seeds". As a result of completing required tasks the student will obtain practice in measuring, counting, estimating, and graphing. The scientific processes practiced in this activity are sorting, classifying, observing, recording, and comparing. Evaluation will be based on completion of each task.

Multi-Cultural Aspect:

Dr. George Washington Carver was a great scientist who found many ways to use plants. He made more than 100 different things from corn. As an extension to this exercise you may bring in different dishes prepared in the manner of different ethnic groups. An example might be a preparation of a bean burito which is a food prepared by the Hispanic culture.

Reference:

Project Aims K-3, **Primarily Plants**, 1990.

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Algae--Where does it Live?

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Objectives:

1. To understand what green algae is and where it grows.
2. To test the growth of algae in four different types of water - lake water, well water, distilled water and tap water.
3. To watch and record the growth of algae.

Materials needed:

Types of water:
- Tap
- Well
- Distilled
- Lake Michigan

Four (4) quart jars

microscopes
slides (concave)
cover slips
medicine droppers
pipette
pencils
plastic or glass covers

Strategy:

Display a gallon of lake or pond water to the class. Have students observe the water and describe what they see, especially the "green growth". Discuss what they think this growth is, such as, plant life. Name the plant -- ALGAE.

The teacher will then distribute a worksheet and have the students list the characteristics or traits of the algae plant. They will also hypothesize about which type of water algae can grow in best (distilled, lake, well or tap) and why.

Set up two microscopes with a sample of chlorella--a type of green algae. The class will then be able to identify algae in their projects.

Divide the class in groups. Each group will have a sample of well, tap, distilled and lake water. They will also have a sample of chlorella. They will place a drop of chlorella and a drop of one type of water on the microscope slide. Students should observe and draw a picture of what they see. They will observe four types of water.

The teacher will distribute four quart jars labelled WELL, TAP, DISTILLED and LAKE water. Each jar will be filled approximately 3/4 full of the above types of water. Using a pipette, 10 cc of lake water containing algae will be added to each type of water. A pencil will be placed over the jar and covered with a plastic or glass lid to allow air to enter.

Observe the algae growth in each jar for 2 to 3 weeks. Record results twice a week on a chart by taking a sample of the water and placing it under the microscope. They may also observe the growth (or lack of growth) without a microscope but this may be more difficult to record results.

Extensions:

You may want to check the pH level of the water for different results.
You may want to add fish (same kind) to each container of water to see if this affects the growth of algae.
You may also duplicate a culture of algae in lake water, prepared as described above. Shield algae from sunlight with transparent colored paper to determine which color of light is necessary for algae growth.

Evaluation:

Did the class understand the scientific method used in this experiment? (same jars, same amount of water, same amount of algae in each type of water.)
Were the students able to observe and record results?
Did they questions results?

LAB SHEET

GREEN ALGAE--WHERE IS IT FOUND

1. List 2 or 3 characteristics or traits of green algae.

2. HYPOTHESIS (OR SCIENTIFIC GUESS). In which type of water will green algae grow the most? Will it be well water, distilled, tap or lake water. Why?

3. Using a microscope, draw the algae you see in a drop of each type of water. Do this twice a week for at least two weeks.

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What are Some Substances That Will Cause Algae To Grow?

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Objective:

Students will learn how to set up a controlled experiment. Students will be able to determine the effects of oil, detergent, copper crystals sulfate and lawn fertilizer have on the growth of algae.

Materials Needed:

4 large jars
glass plates (lids)
pond water
markers for glass jars
4 pencils #2
laundry detergent powder
dry lawn fertilizer
copper sulfate crystals
graduated cylinder

Procedure:

1. Collect 4 quart jars. Clean each jar with soap thoroughly. Make sure the jars are rinsed thoroughly, so that there are no leftover traces of chemicals. Fill each jar about three-fourth full with distilled water.

2. To each jar add 10 milliliters of pond water. Before measuring the pond water, stir the water thoroughly.

3. To the first jar, add 15 grams of detergent. Label this jar #1, detergent.

4. To the second jar, add 15 grams of lawn fertilizer. Label this jar #2, lawn fertilizer.

5. To a third jar, add 3 or 4 small crystals of copper sulfate. Label this jar #3, crystals copper sulfate.

6. To a fourth jar, add 15 milliliters of oil. Label this jar #4, oil.

7. Do not add anything to the fifth jar. Label this jar #5, control jar.

8. Use the glass-marking pencil to mark the water level in each jar and then place a glass plate over each jar. Prop up one side of the glass plate by laying a pencil over the edge of the jar so that air can get into the jar but so that dust and dirt will not settle into the jars from the air.

9. Set all the jars in a well-lighted place, but not in direct sunlight. Observe the jars each day for about 2 weeks. If so much water evaporates from the jars that you think the results will be affected, add distilled

water to bring the water back up to its original level.

Recommended Strategy:

Discuss orally what is meant by a controlled experiment and a variable factor. Using two identical plants, have students follow procedures in setting up a controlled experiment. Students will learn how to apply the scientific method by setting up an experiment showing the effects various substances have on the growth of algae. Divide students into four groups picking a number 1 thru 4. Each group will be given four cleaned jars containing a measured amount of distilled water, detergent, oil, lawn fertilizer and copper sulfate. Students will be given a worksheet to answer one of the question stated: What they already know about algae and what they want to learn? Students will answer the follow up questions after the experiment is completed. What did they learn? Students will be given unlabeled pictures of green algae along with a wet mount of algae. They will be asked to compare the algae on the wet mount with the pictures and to identify the type.

Analysis:

1. Define scientific method? What are the steps?

2. Why is it important that the jars be cleaned before beginning the project?

3. Which jar do you think will have the greatest and least amount of growth?

4. What might be some reasons why algae would grow in some jars but not in others?

5. How do you think copper sulfate would affect the growth of algae?

6. What is a controlled experiment?

7. What are the two groups in a controlled experiment? Explain how they differ.

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The Parts of A Perfect Flower

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Objectives:

Upon completion of this lab activity, the student will be able to
(1) identify each flower part.
(2) explain the role of each flower part.

Materials needed:

(1) Gladiola/lilies
(2) razor blades
(3) glass slides
(4) paper towels
(5) markers
(6) glue or scotch tape
(7) construction paper
(8) toothpicks
(9) two dissecting microscopes
(10) overhead projector
(11) prepared lab sheets
(12) prepared transparency

Strategy:

(1) The students should study the model of the flower and determine whether the flower is complete or incomplete, perfect or imperfect. The students should now focus their attention on the diagram of the flower and label all flower structures.
(2) The students should carefully dissect the flower, answer questions and do the required drawings.
(3) As the students dissect their flower, use the overhead projector to show each flower part.
(4) Have each student or each group of students tape or glue and label each flower part on construction paper.
(5) Have the students observe pollen grains and ovules under the dissecting microscope.

Student Activities:

Part A: The Sepals and Petals. Carefully examine your specimen. Trace the stem to the base of the flower.

(1) Does the stem appear wider as it nears the base of the flower?
(2) What is the thick part of the stem called?
(3) What is its function?
(4) Do you see green leaves surrounding the bottom of the flower?
(5) What are they called?
(6) How many can you count on your specimen?
(7) What is their function?

Observe the colored petals of your flower

(8) How many are present?
(9) What advantage to the flower are colored petals?

Part B: The Pistil and Stamen. Carefully remove enough sepals and petals from your flower so that you can observe the inner parts. Do you see a large stalklike part in the center of the flower? This part is called the pistil. It is divided into three areas. The large, bottom part is called the **ovary**, the middle area is called the **style** and the top part is called the **stigma.**

(10) Draw and label the three areas of the pistil: **stigma, style and ovary.**

Surrounding the pistil are several upright stalks.

(11) What are these called?
If you observe carefully, you can see structures attached to the tops of the stalks.
(12) What are these called?
(13) What do they produce?

Part C: The Ovary. Carefully remove the pistil from your flower. With your razor blade, cut across the ovary.

(14) What do you see inside the ovary?
(15) What is the function of the ovary?
(16) What is the biological function of the flower?
(17) Draw the stamen and label the **anther** and the **filament.**
(18) Name the three ways that pollen may be carried.
(19) What is a perfect flower?
(20) What is a complete flower?

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Photosynthesis: A Controlled Experiment

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Objective

To measure the amount of starch left in a leaf of a geranium plant under the following conditions; carbon dioxide increased, decreased and neither increased or decreased.

To prove increased starch increases the process of photosynthesis in the green plant.

Apparatus Needed

3 Geranium Plants (same size, shape and color)
3 2 gallon plastic bags with twist to close
2 250ml Beakers
1 500ml Beaker
1 Hot Plate
1 Pair of Plastic Tongues
4 Petri Dishes
1 1pt. 91% Isopropyl Alcohol
1 Package of Alka-Seltzer
1 50mL of Soda Lime
1 Bottle of Potassium Iodide
3 Pieces of Cardboard
1 Pitcher of Water

Recommended Strategies

1. Mark plants A, B and C.
2. Put cardboard pieces at the bottom of each bag.
3. Put plant A in one bag with one 250mL beaker half filled with water. Place Alka-Seltzer in water, twist close.
4. Put plant B in one bag. Put 50mL of Soda Lime in a Petri dish and place in bag with plant B, twist close.
5. Put plant C in one bag. Twist close. (This is the "control" plant.)
6. Find a sunny place in your classroom to place all three plants. (The plants must have same amount of sunlight and water.) The plants are to set for one day.
7. After one day, remove plants from bags. Break off one leaf from each plant put in Petri dishes marked A, B, and C.
8. Half fill the 500mL beaker with water.
9. Fill the 250mL beaker with alcohol.
10. Place beaker with alcohol into beaker with water, on to the hot plate.
11. Take leaves one at a time and put in beaker with hot alcohol. Leave in for ten minutes.
12. Remove leaf with plastic tongues.
13. Place leaf on paper towel to dry, then place in Petri dish.
14. Place several drops of potassium iodide on each leaf.

15. Observe color change of the three leaves. (the darker the color (purple) the more starch. The lighter the color, the less starch.

Conclusion

To determine how much starch is left under three conditions.

1. Carbon Dioxide increased.
2. Carbon Dioxide decreased.
3. Carbon Dioxide neither increased or decreased.

Discussion

1. What were the results of plant A, with Alka-Seltzer? Was the carbon dioxide increased, decreased, or remained the same?
2. What were the results of plant B, with the soda lime? Was the carbon dioxide increased, decreased, or remained the same?
3. What were the results of plant C, the "control" plant? Was the carbon dioxide increased, decreased, or remained the same?

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Four Parts of a Green Plant and the Functions of each Part

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Objectives

The learner will learn four parts of a green plant and the functions of each part.

Apparatus Needed

An apple; bag of tea; two stalks of celery (a stalk of raw celery and a stalk of celery in colored water); an onion in a cup/glass of water; one sweet potato in a cup/glass of water; four posters (each poster should show pictures or drawings of a part of the green plant.......roots, stems, leaves, and the flower); several packages of different green plant seeds; different kinds of green plants (with and without flowers). **Optional** Four milk cartons (soil should be in each milk carton); four 5x7 cards with the name of a part of a green plant on each card.

Recommended Strategy

Display the following foods on a table: an apple, a bag of tea, an onion (in a cup or glass of water), and a stalk of raw celery. Have the students identify the foods on the table. Discuss what the foods have in common. Try to come to a general conclusion that the foods on the table come from green plants.

Display a live green plant and ask students to identify the parts of the plant. As the students identify the roots, stems, leaves, and flowers, have another student point out the part that was identified. For each student that correctly identifies the roots, stems,leaves, and the flower, give him/her a milk carton and a package of green plant seeds.

After identifying the part of a green plant, have the students give the order in which the plant will grow starting with the seeds. As the students determine the order in which the plant will grow, display posters with pictures of each part of the green plant.

Discuss the functions of each part of the green plant: roots a) take in water from the soil; b) take in minerals; c) store excess food; d) transport water and food to other parts of the plant; and e) hold or anchor the plant in the soil.

stems a) support the plant; b) expose the leave to sunlight; c) transport food and water to other parts of the plant; and d) sometimes, photosynthesis (food) is made in the stem.

leaves a) take in carbon dioxide; b) release oxygen (the exchange of gases.....taking carbon dioxide into the leaves and releasing oxygen out of the leaf...... is referred to as respiration); c) chlorophyll; d) photosynthesis; and e) take in energy from the sun.

flower a) sexual reproduction.

Optional

1. Have the four students that were given milk cartons with soil and seeds plant their green plant seeds. The plants will remain in the classroom for class observation.
2. Play the game "Plant Charades". Divide the class into four groups. Give each group a card with the name of a part of the green plant written on it. Each group will have 5 minutes to suggest ways to demonstrate the part of the plant without talking. The winning group will be the group that guesses the most parts of the plant.
3. Use the celery in colored water to demonstrate how water and minerals travel through plants.

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The Effects of Light and Temperature on the Growth and Development of Plants

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Objectives

1. To show how visible light constitutes only a small part of the spectrum of radiant energy.
2. To show how light can be separated into a variety of colors if passed through a prism.
3. To show that certain colors correspond to different wavelengths of the light present.
4. To show how certain wavelengths are reflected by plant pigments and others are absorbed.
5. To show that when plants are grown in different wavelengths and temperature variations,the size,color and the length of their growth processes are affected.

Equipment and Materials

overhead projector
Early Scarlet Radish Seeds
two thermometers
12 mini peat plant pots
two trays or containers
labels
Polaroid Camera
12 medium peat plant pots
vermiculite
plant food
water
two quart bottles
graph paper
small metric ruler
green and red transparency paper
clear transparency sheets

Recommended Strategies

Review light waves using a prism. Show how light waves can be separated with a prism. Show the different colored light waves. Show how some of the colors can be reflected and others can be absorbed. Encourage students to list the size, color, height, number of leaves, etc., from plant samples given.

Using five groups of students, distribute two samples of experimental plant samples to each group. Also, distribute data sheets to each group. Students will observe and record observations. Plot the temperature and growth patterns on a graph.

Procedure for growing radish plants: Obtain 12 mini peat pots. Fill each pot to the halfway mark with vermiculite. Plant 10 radish seeds in each pot. Cover them with a thin layer of vermiculite. Water them thoroughly, using a diluted solution of plant food. Use red and green transparencies to cover two pots with red and two pots with green. Use different shades of green and red transparencies to cover one with red and one with green. Place three uncovered plants with the plants covered with the colored transparencies in the sunlight. Observe and record data on a daily basis. Place three uncovered pots in a dark room. Observe and record data daily. Record data on the length, size, color, number of leaves and temperature for each experimental plant sample.

Please note: Each experimental plant sample received a normal day without any manipulation of temperature.

After 10 to 15 days of observation and recording data, place two of the plants covered with red transparency (plants grown in sunlight) in the darkness. Repeat the above procedure using plants covered with green transparency and plants not covered. Place two of the plants grown in a dark room in a sunlit environment. Observe and record data daily. Record data on the length, size, color, temperature and number of leaves for each experimental plant sample.

Use photographs taken with a polaroid camera to show stages of development. Use graphs and charts to plot and make an analysis of the growth processes of plants' responses to visible light wavelengths in relationship to the temperature.

Summary

Plants usually respond to light, touch and temperature. They respond with leaves, flowers and fruit. Visible light can be separated into different colors. Some colors reflect light while others absorb light. A difference in light wavelengths will significantly affect the length, color, germination period, number of leaves, quality and quantity of fruit. Darker shades of green and red transparency sheets produced a significant degree of change in plant development compared to lighter shades of red and green. Temperature differences were slight and not controlled. All plants received a normal temperature during the experiment.

Note: all plants grown in the light received a full day of sunlight. All plants grown in a dark room received a full day of darkness. All plants were watered at the same time using the same amounts of water from the diluted plant food. All data was recorded at the same intervals.

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From Flower to Fruit

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Objectives

1) Students will learn that flowers have essentially four parts.
2) Students will learn both the male and female reproductive parts of the flower.
3) Students will learn about self-pollination and pollination by insects and other animals.

Equipment and Materials

Petri dishes
Dissecting kits
Scotch tape
Magnifying glasses
Saran wrap
Construction paper
Overhead projector
Prepared transparency
Prepared worksheets
Silk scarf
Pictures

Lily plants
Geranium plants
Gladiola plants
Apples
Spices
Fruits
Nuts
Olives
Honey
Indigo

Recommended Strategies

Display flowers, scarf, pictures and edible items at front of the classroom.

(Phenomenological Approach) - Students will answer questions about the flowers, honey, dye, pictures, etc. Example: What do you notice? Possible answers: flowers, fruit, colors, etc. Show picture of bee pollinating flower. Ask: What do you know about bees and flowers? Possible answers: Bees make honey, insects pollinate flowers.

Students will use handouts to identify the parts of a flower and the sub-parts.

Demonstrate the parts that are male and female by use of the overhead projector.

Use a transparency of flower diagram.

Use a sample flower (lily) to show the studied parts.

Pass the lily around the classroom for each student to see.

Students will show knowledge of the parts of a flower by dissecting a lily and/or a gladiola. They will affix each part on a prepared sheet and label the parts.

Show picture of apple flower and cross-section of an apple. Teacher will cut an apple in half and show the remnants of the pistil. Teacher will cut the apple crosswise to show the ovules. (eggs)

Students will eat products of the flower: seeds, nuts, raisins, etc. Students will observe the cut apple and cross-section and then eat the parts. Students will color labeled sheets for take-home or bulletin board display. Students will place dissected plant sheet on construction paper for bulletin board or take-home.

Optional

Dissect pollen tubes and count number of pollen grains. Calculate length of time it takes pollen to travel down the tube using worksheet suggested from United Graphics. (see resources) Rate = distance/time

Resources

Funeral Homes
Flower Power, United Graphics, Inc. 1979
Leo's Florist 407 E. 71st Street 723-6579
The Botany Coloring Book (see Nasco Science Catalog)

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The Effects of Over Exposure to Ultraviolet Radiation on the Growth of Plants and Bacteria

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Objective:

Students should be able to explain the deleterious effects of ultraviolet radiation on the growth and development of plants and bacteria. Also students should be able to describe the effect of ozone on ultraviolet radiation.

Materials:

String bean and mustard green seeds, ultraviolet lamp, glass apparatus, potting soil, water trays, pots for the plants, glass plate, slide projector, autoclave, fluorescent poster board and chalk,
slides, E.Coli bacteria, nutrient media, petri dishes, petri dishes with nutrient agar, incubator, bunsen burner, test tube racks, NaCl, cardboard box, ring stand

Strategy:

Two experiments were performed to demonstrate the effect of ultraviolet radiation on plants and bacteria. Another experiment was performed to further demonstrate how glass filters ultraviolet radiation. The glass was used to mimic the effects of ozone on ultraviolet radiation.

Experiment 1:

1. String bean and mustard green seeds were germinated on cotton in petri dishes for 3 days. During that time, the seeds were given a few drops of water daily.
2. On day 4, the germinated seedlings were transferred to the pots containing potting soil. Each seed type had two test groups and one control group. Eight plants were used in each group.The two test groups differed in that one was shielded by glass when exposed to ultraviolet radiation (u.v.r.) -labeled (SE)- but the other was not shielded when exposed to u.v.r. and it was labeled (U.S.E.).
3. From day 5 to day 10 the test groups were exposed to (u.v.r) for 2 hours daily.

Experiment 2:

1. Expose a fluorescent surface to u.v.r.in a dark room.
2. Expose the fluorescent surface to u.v.r. but this time place a glass plate in front of the u.v.r. lamp.

Experiment 3:

1. Grow E.Coli cells in nutrient media for 24 hours.
2. Take out 1 mL of the E.Coli cells to use as the control group. Do not expose this group to u.v.r..
3. Expose the remainder of the cells to ultraviolet light.

4. At 5, 20, and 60 seconds take out .1 mL of E.Coli cells
   Place each group of cells in separate test tubes and label each one.
5. Dilute each group of cells to 10-6 concentration and plate out
   .1 mL of cells on nutrient agar then incubate for 24 hrs.

Conclusion:

Experiments have shown that ultraviolet radiation damages and kills the cells of living organisms. The experiments performed in this project alone demonstrate this. We see examples of its deleterious effects not only in plants and bacteria but in human beings as well. Skin cancer is an example of this. It is caused by ultraviolet radiation being absorbed by our skin cells.There are, however, protective mechanisms in our bodies and in our environment that function to minimize or prevent the deleterious effects caused by over exposure of living organisms to ultraviolet radiation. Pigment, present in the skin of most human beings, and ozone, present in the stratosphere, both serve to absorb ultraviolet radiation.

References:

Regan, James and Parrish, John **The Science of Photomedicine.** Plenum Press, New York Medical School.

Biswas, Asit **The Ozone Layer** Plenum Press.

Giese, Arthur **Living With Our Sun's Ultraviolet Rays.** Plenum Press: New York

Ellis, Carlton and Wells, Alfred **The Chemical Action of Ultraviolet Rays.**

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Showing Nature's Way-Plant Development and the Plant Parts We Eat

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Objectives

The student will demonstrate and record the stages of plant growth.
The student will categorize food plants by identifying the edible part.

Apparatus needed

1. Live bean pods, sprouts, and plants showing blossoms and beans.
2. Posters showing the plant stages.
3. Blackboard with 32 squares for listing and picturing the parts of the plant we eat.
4. Duplicated copies of the song and illustrated booklet (or plain paper to fold into 8 squares for writing and drawing a booklet. Long plain paper to be folded into 32 squares for making a chart of the plant parts we eat.
5. Scissors, pencils, crayons and colored chalk.
6. Fresh vegetables to show as examples.

Recommended strategy

Pantomime the stages of plant development. Students signal with thumbs if they understand each stage. Discuss the meanings. Pass song sheets and all act it out while singing the song.

Guided practice-Students point at posters showing diagrams and indicate the vocabulary words labeling the parts.

Independent practice-Students make an 8 page booklet showing the stages of development in a bean plant, labeling the parts with vocabulary words, and coloring it correctly.

Observation-Pass bean pods. Students open them to see the seeds. Pass bean sprouts. Students open the seed food to see the tiny leaves. Pass bean plants in the stages of development; showing the stem, the leaves, the blossom and the seed pod.

Check for understanding-Ask students to identify what they see.

Extension-Other Edible Plant Parts. Students fold a large paper into 32 boxes for a chart. Model on the blackboard; Title-Plants We Eat, one category in each box going down the right side of paper- seeds, sprouts, roots, stems, leaves, blossoms, fruits. Show a sample of fresh vegetables for each category. Students name three examples for each category and color a picture, labeling it, for each box across the paper. Volunteers fill in the blackboard chart, and all fill in individual charts.

Review-Sing "A Hole in the Ground" (a progressive song describing what grows from the hole; roots, stem, branch, leaves, blossom, fruit and seeds.

Next step-Read and explain the booklet and chart to someone at home tonight, and be ready for a test tomorrow on labeling the parts of a plant. Try sprouting corn seeds and bring in the various stages of development for extra credit.

Song

A tiny seed is sleeping in the ground, sleeping in the ground, sleeping in the ground.
A tiny seed is sleeping in the ground, showing nature's way.

The sun comes out and warms the seed, warms the seed, warms the seed.
The sun comes out and warms the seed, showing nature's way.

The rain comes down and wets the seed, wets the seed, wets the seed.
The rain comes down and wets the seed, showing nature's way.

The roots grow down and spread their toes, spread their toes, spread their toes.
The roots grow down and spread their toes, showing nature's way.

The leaves are growing inside of the seed, inside of the seed, inside of the seed.
The leaves are growing inside of the seed, showing nature's way.

The stem humps its back and stands straight and tall, stands straight and tall, stands straight and tall.
The stem humps its back and stands straight and tall, showing nature's way.

The leaves grow out and wave in the breeze, wave in the breeze, wave in the breeze.
The leaves grow out and wave in the breeze, showing nature's way.

The blossoms grow and look beautiful, look beautiful, look beautiful.
The blossoms grow and look beautiful, showing nature's way.

The fruit grows out with its new seeds, with its new seeds, with its new seeds.
The fruit grows out with its new seeds, showing nature's way.

A tiny seed falls back to the ground, back to the ground, back to the ground.
A tiny seed falls back to the ground, and starts the great replay.

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GERMINATION: NAME THAT SEED

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Objectives:

1. The student should gain an appreciation of the complexity or the seed.

2. The student should be able to recognize and differentiate between the male and female reproductive organs of a flower.

3. The student should be able to differentiate between a monocot and a dicot seed.

4. The student should be able to associate germination time with the growth of the young plant.

Materials: Corn seeds, corn stalk, gladiolas (flower), soaked corn seeds, soaked bean seeds, single edge razor blade, magnifying lenses, glass jars (showing germinating bean and corn seeds).

Strategies: The student walks into the classroom and finds on their desks a large corn stalk and a tiny corn seed. The students begin to examine the two. The teacher observes them for a few minutes. The teacher begins to question them concerning what they are examining.

Suggested questions:

1. What are you observing?
2. What is the relationship between the seed and the stalk?
3. Which one of the life processes has to have taken place to get the stalk from the seed?
4. What kind of reproduction has taken place?
5. What is the first step in sexual reproduction?

GLADIOLAS (Flowers):

6. What are the names of the male and female reproductive organs?
7. Which organ will put their gametes into the other?
8. Why is the stigma sticky?

GLASS JARS (Containing germinating seed and plants)

The teacher will then give each group of students a set of germinating seeds and plants which has been started at different intervals. The seeds were soaked over night and

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placed in glass jars between the glass jars and the paper towels. The students moisten the seeds daily and watch for the germination of the plant.

Materials: Corn seeds; Corn stalk; Germinating beans and corn seeds; tobacco flower

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Cell Structure and Function

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Objectives:

Discuss scientific advances brought about by the Mars Surveyor Space Program which impact on daily life, especially any animal and plant cell movements.
Identify laboratory apparatus like microscopes, slides and coverslips; use the microscopes to view cells and organisms.
Learn vocabulary pertaining to cells.
Draw and color what is seen under the microscope.
This lesson could be used for grades 3rd-5th.

Vocabulary:

cell membrane	endoplasmic reticulum
cytoplasm	golgi bodies
nucleus	Paramecium
mitochondria	Euglena
lysosomes	Ameoba

Materials Needed:

Newspaper articles about the Pathfinder landing on Mars. Microscopes, slides and coverslips, flowers and onions, posters of enlarged animal and plant cells, plant and animal cell component labels, cartoon posters of 3 types of cells and various strands of human hair, Elodea specimen and pond water (Elodea is a commercially available alga). This is a list of materials for each student in the class with the exception of microscopes: posters of enlarged animal and plant cells and cartoon posters of Paramecium, Euglena, and Amoeba; lemon gelatin dessert mix; l pint (125-ml) resealable plastic bag; quart bowl; large grape.

Strategies:

1. Classroom discussions about the Mars Space Program.
2. Articles on the Mars space program read aloud in class followed by role playing.
3. Locating articles that discuss possible fossils of cells found on Mars.
4. Using a slide to observe Elodea specimen under the microscope.
5. Observing what type of movement the specimen is making.
6. Flagellar, ciliate, and amoeboid motion will be looked for under the microscope.
7. Predict the condition of hair by observing a strand under the microscope.
8. Determine which end of the hair strand was attached to a live cell.
9. Gather some pollen from a flower, place it on a slide, and observe the pollen under the microscope.
10. Draw the cells you see from items 4, 8, and 9 above on a sheet of paper; color the cells.
11. Observe the same slide 30 minutes later or the next day to see what changes occurred.
12. A cooperative team will use a small picture of the animal cell that is

labeled with the parts of the cell to identify the same parts on the enlarged poster of the animal cell that is not labeled.

13. The other cooperative group will place and paste the parts of the plant cell on the enlarged poster of the plant cell using the small labeled picture of the plant cell as a guide.
14. Each student will make a World-Class Cell Model.
    a. Have an adult helper mix the ingredients for the gelatin dessert according to the instructions on the box.
    b. Allow the gelatin to cool to room temperature.
    c. Pour the gelatin into the resealable bag, seal the bag, and place it in the bowl.
    d. Set the bowl and bag in the refrigerator and chill until the gelatin is firm (about 3 to 4 hours).
    e. Remove the gelatin from the refrigerator and open the bag.
    f. Using your finger, insert the grape into the center of the gelatin
    g. Reseal the bag.
    h. Place the bag of gelatin on a flat surface such as the kitchen counter. Observe its shape.
    i. Hold the bag over the bowl as you gently squeeze it (the bowl is used in the event that you squeeze too hard and the bag opens). Observe the shape of the bag as you squeeze
15. Thin layers of onion cell skin will be prepared, placed on slides, covered with coverslips, and observed under the microscope.
16. Write a rap or poem concerning the structure and/or movement of cells.

Performance Assessment:

1. Students will share the articles on Mars with role playing.
2. Students will take a multiple choice quiz on the hierarchy of the organizational levels of living things. Below is an example of testing students on knowing the difference between cell, tissue, organ, system and body. You may rewrite it leaving cell off each item.

   Directions: On the quiz below one list would be in a correct order if you were to write organ in the blank. Which list is that?

   a. cell, tissue, system, body, ______
   b. cell, tissue, ______, system, body
   c. ______, cell, tissue, system, body
   d. cell, ______, tissue, body, system

3. The nature of movements of cells in the human body will be discussed.
4. The labeled posters of plant and animal cells will be read aloud.
5. A simple model of a cell with 3 parts will be made.
    a. Each student will understand that the plastic bag represents the membrane of the model cell.
    b. Each student will properly name the pale color of the gelatin dessert as the grayish jellylike material cytoplasm, that fills the cell.
    c. Floating in the gelatin is a grape the represents the nucleus.

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Mold Investigations

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Objectives:

This activity will allow students to observe how molds grow. It will also allow them to investigate the fact that there are many types of molds and that their spores exist in various locations (even in the classroom). Possible modifications/additions allow students to design experiments and use the microscope. This exercise is appropriate for grades 3-8, and discussions can be scaled as required.

Materials Needed:

Each student will need 3-5 slices of bread (inexpensive white bread works fine) and a zip lock sandwich bag for each slice of bread. A simple water spray bottle is also needed. For additional modifications access to a refrigerator is useful. For microscopic observations about 4 microscopes, about two dozen microscope slides and cover slips, and several sets of tweezers are adequate for a class of 20-25.

Strategy:

Give each student several slices of bread and a zip lock sandwich bag for each slice. Each student should find a place in the classroom, hall, etc. and wipe an area in that place with a slice of bread. The slice should be sprayed **lightly** with water and then sealed inside the bag. This can be repeated for other locations with additional slices of bread. Each bag should be labelled with the student's name, the date, and the location which was wiped with that slice. The bags can be stored in a central location or taped to the students' desks to make daily observations more convenient. The students can examine their specimens each day and record their observations in a notebook. It may take 7-10 days or so for visible growth to appear (longer in the refrigerator (see below)), so don't be alarmed if you don't see something after only one or two days.

Controlled experiments can be easily adapted from the basic procedure described in the previous paragraph. For example, two or more slices can be wiped in the same area, but incubated under different conditions. One possibility is to omit the water spray from one slice to investigate whether the water spray enhances the mold growth (here, the unsprayed slice is the "control" for the effect of the water spray). Other experiments could include wiping the same area with several slices, spraying them all, but incubating them under different conditions (e.g., at room temperature or in a refrigerator (here the room temperature incubation is the control for the incubation in the cold); exposed to the light or in a dark location (here the dark incubation is the control for the effect of light); etc.).

If microscopes are available, they can be used to examine the mold that grows (see **Performance Assessment** section below). For each specimen place a drop of water in the middle of a microscope slide. Use the tweezers to sample a small bit of mold from a piece of bread and shake the sample off in the drop of water. Cover the water/mold with a cover slip. Examine under the microscope beginning at the lowest power and then going to higher power if desired. Make sure, however, that you know how to use the microscope before trying this.

Performance Assessment:

After about 7-10 days mold should begin to grow (it may take longer in the refrigerator or for the samples that were not sprayed with water). Microscopic mold spores (which are single cells) exist almost everywhere. When they land on a food source (such as a slice of bread), they begin to multiply and eventually grow into a large, multicellular organism, which can be seen with the naked eye. Different species of molds have different colors, textures, etc. in these "macroscopic" forms, and so students should be able to make a crude estimate of how many different types of molds they are growing. They can see, for example, if different types of mold were wiped from different areas. The experiments with variation of water, temperature, or light will allow the students to see if these variables affect the rate of growth of all or some types of mold. After the mold has grown up on the bread slices, the microscopic observation can be an exciting end point for the exercise, as the students observe and compare the structural details of their various molds (even at the cellular level) with those details that they see with the naked eye.

Students can be assessed on the thoroughness of their notes, the care with which they set up their controlled experiments, and the sophistication with which they explain their results.

References:

Any high school or college general biology textbook should have ample sections on this material.

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Micro-organisms

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Objectives:

This lesson has been developed for 6th grade students, but is easily adaptable to other levels.

Students will: -follow written directions
-discover additives which will deter micro-organism growth

Materials Needed:

-250 ml beaker
-jar of bouillon (either beef or chicken will work)
-water
-3 test tubes
-labels "salt", "vinegar", "control"
-test tube rack

Strategy:

One (1) bouillon cube is to be dissolved in 250 ml of very warm water. As the cube is dissolving, add 1 t of salt to the test tube labeled "salt"; 1 t vinegar in the test tube labeled "vinegar". Pour equal amounts of the bouillon into the test tubes. The salt may NOT dissolve quickly, but **leave it alone**-if you try to stir it in, you may remove some of the salt, or "blurp" it, losing some of the liquid, or contaminate another container by using the stirrer more than once.

With the test tubes arranged in the rack, LEAVE ALONE, uncovered for 2-3 days. This can take place over a weekend. Spores will drop into the tubes from the air. Perhaps a duplication of Pasteur's experiment would be helpful at the same time: put bouillon into 2 containers, one open to the air straight up, and one open to the air, but the opening is off to the side so that things could not "drop" into the container. Compare these two containers to show that things "dropped" in from the air, and did not spontaneously grow in the containers.

Students are to examine and record their findings.

Discussion. Most will find the control tube to be very cloudy and the other two will be less so. Both salt and vinegar inhibit the growth of micro-organisms.

Performance Assessment:

The outcomes of each student should indicate that the directions were followed, therefore PASS. Any other outcome will be a fail for the first objective, that of following written directions. Teacher may use discretion in allowing a repeat of the experiment for half credit; 3/4 credit for a 2-3 paragraph identifying the cause of the different outcomes.

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Micro-organisms

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Objectives:

This lesson has been developed for 6th grade students, but is easily adaptable to other levels.

Students will:

-assemble a wet-mount slide
-demonstrate the use of a microscope, focussed on the specimen
-demonstrate the mastery of observation
-utilize vocabulary of mold structural parts in journal and/or presentation/questioning by Teacher

Materials Needed:

Paper towel or paper napkin
Clean, blank slide(s)
Slide cover(s)
Water
Mold from piece of bread
Forceps
Microscope

Strategy:

In preparation for this lesson, students/teacher will **already** have prepared some bread mold. I usually wipe the classroom floor (if uncarpeted), a chalk ledge, or window sill with half a slice of home-made bread. I lightly spray it with water, and then EITHER place in a sealed baggie, OR lay on a saucer in an out-of-the-way place. If you use the saucer method, you may need to re-moisten the bread every day or two.

Once the mold has started to grow (2-3 days), you may want to allow it to dry out, so that student(s) or you who are sensitive to molds will be less so. I **ALWAYS CAUTION** against touching or breathing the molds.

Part A (I usually give the directions for making a wet-mount 3 times; tell, show, tell. My directions differ from our science text.) Place a clean slide on top of a paper towel or piece of paper. Place 1 or 2 drops of water on it. (Use the tip of your finger, or use a dropper.) With the forceps, take a TINY pinch from the bread mold and MASH around into the water. (Tiny because we are using a microscope, and just a bit will look big; the mold structures are sturdy, and will not be harmed. Having them spread out will allow the light of the microscope to shine through it so the structures can be easily seen.) Holding the slide cover by the sides between forefinger and thumb, slide 1 edge TO THE EDGE of the water droplet, and then DROP the cover on to the slide. (If there are any air bubbles, they will show up as silver shapes, but should not be a problem.)

Part B Secure the slide on the platform with the slide clips. (Holds the slide steady for viewing.) Make sure that some of the mold is over the light which is coming in via the mirror or lamp. Then with the lowest-powered lens (usually the shortest) in place, focus by slowly turning with the coarse adjuster until you see something; then adjust the fine knob until the "picture" is clear. DRAW what you see in the journal, or on the observation sheet. LABEL the ball-like top "sporangium", and the stem AND root-looking parts "hyphae". COMPARE it with your team members.

Performance Assessment:

A. Can prepare a wet-mount slide, using material from the experiment

	slide cover atop slide specimen	1
	slide cover indicates air bubbles-some	1
	-few	2

B. Can put a slide on the microscope platform

	light shining on specimen in lens	1
	specimen focussed-somewhat	1
	-sharply	2

C. Can label/name	-microscope parts (max. based on YOUR microscope)	
	1 pt. per part	0-6
	-mold parts	1-2
	-did drawing	1
	-labeled drawing	1
	-1 pt. per part labeled	1-3

PASS = 11 pts. or more; FAIL = 10 pts. or less.

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Cell Division and Mitosis

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Objectives:

1. For grades 9-12 (may be modified for younger).
2. Students will make a slide of onion root tips and observe different phases of mitosis.
3. Students will be able to state why cells divide.
4. Students will draw the different stages of mitosis and try to arrange them in order of division.
5. Students will demonstrate each phase of mitosis and the main characteristics of each.

Materials:

1. Prepared onion root tip mitosis slides.
2. In place of these and to promote interest, students may set up their own slides. Materials needed per slide are: fresh grown onion root tip, 5-10ml distilled water, 5ml 6M HCl, 1 ml Feulgen reagent in a vial, 5 ml 45% acetic acid, dropper pipette per solution, beaker, slide, coverslip, and a pencil with eraser or small cork to squash the slide. Materials needed per class are: 5-10 ml Carnoy's solution (1 glacial acetic acid : 3 absolute alcohol) in vial, 2-3 cups and onions, and toothpicks.
3. A microscope per student or pair.
4. Two different colored pipe cleaners cut at varied lengths to represent chromosomes for assessment (4 chromosomes per cell). I use 2 long and 2 short blue pipe cleaners and 2 long and 2 short red pipe cleaners connected with beads which represent the centromeres. This model would use the long pipe cleaners as a homologous pair of chromosomes and the short as another pair. Two pipe cleaners of each size and color are used to model replication. Each chromosome is composed of two chromatids.

Strategy:

This lesson would be used after cells have been observed with microscopes in the lab. After a review of cell parts, the teacher would exhibit the onion (or prepared slides) and explain that root tips have been cut for the students to observe. Explain that the stain to be used in this preparation is different because something will be noticeable that could not be seen in past labs (chromosomes). Try to have the students guess this by questioning them about the cells they are observing - i.e. dividing cells - and how these are different than previous cells observed. Nuclei were observed before but not the chromosomes.

LAB

Students are more eager to learn how to set up their own slides and observe them than to use a prepared slide with which they may be unfamiliar. Steps 1-8 explain slide preparation. Go to #9 if prepared slides are being used.

1. Advance preparation:
a. Take an ordinary yellow onion. Cut off any old root growth. Place the onion in a cup of water so that only the root portion is under water. To do this, push toothpicks into the side of the onion which extend outward and hold it on the rim of the cup. New roots should grow within two days.
b. Cut off .5-1 cm of growth at the root tip - enough for all the students.
c. Transfer immediately to Carnoy's solution. After 24 hours, roots should be stored in 70% ethanol in a refrigerator. This stops cell division.

(Steps 2-9 to be completed by students)
2. Obtain a root tip.
3. After obtaining the root tip, pour off the fixative and replace it with 2-5 ml distilled water. Solutions may be poured into a beaker or down the drain.
4. After 1 minute remove the water with a pipette and add 2-5 ml 6M HCl.
5. After 3 minutes carefully remove the acid and wash tissue off with distilled water. Agitate the vial for 1-2 minutes. Discard the water.
6. Use forceps to transfer the tissue to a vial containing 1-2 ml Feulgen reagent. The reagent may be added to this vial if desired. (CAUTION: this dye will stain hands and clothes permanently.) After 20 minutes use forceps to transfer the tissue to a vial containing 5 ml 45% acetic acid.
7. Place 1-2 drops of acetic acid onto a microscope slide and transfer the tissue to the drop. Using dissecting pins and razor blades tease and macerate the tissue into tiny pieces.
8. Place a coverslip over the macerated tissue trying not to get air bubbles under the coverslip. Press down firmly onto the coverslip with a small cork or pencil eraser to spread the cells in a very thin layer. Push down in a perpendicular direction and the coverslip should not break.
9. Once the slide has been prepared or obtained from the teacher, observe it and draw all the different views of cells present under high power. Be careful to observe the nucleus and chromosomes since this is what was not observed previously.

Discussion

1. During the 20 minute stain time (Step 6) it is important to have the students discuss what the cells are doing. Since these cells are in the root tip, they are rapidly dividing. During normal cell activity the chromosomes are unwound and too thin to be seen. During cell division, chromosomes thicken, take up stain and can be easily observed. The students should also try to come up with reasons why cells divide (possible answers: to grow, to repair or replace damaged cells, to reproduce, or to differentiate in the cell cycle of multicellular organisms). Although it is better to have the students elicit these, it may be necessary to give them some of the reasons since this is an introduction. Also at this time explain what is happening in interphase. Cells need to replicate the chromosomes before dividing to ensure that the newly formed cells contain the same genetic material (chromosomes).

2. What the students are observing is an ordered process by which the cells divide the chromosomes so that one copy of each goes to each new cell. Once they have drawn all the different views of cells they have observed, they should share them with their lab groups, the teacher and perhaps the class. Hopefully all the stages of mitosis have been observed and drawn. These can be put on the board or overhead so that the entire class can see all the phases/views and copy them onto their papers. It is not necessary to name the observed cells with a phase of mitosis, but it may be easier so that students can more easily

differentiate them and relate them to a new vocabulary term. Once all the students have drawings of all the phases of mitosis, ask them to arrange the pictures in a way which would show a logical sequence of cell division.

3. Have one member from each group explain what order they put the drawings and why they did it that way. After all students have explained their process, students may wish to choose the model that they think is best. Students should now look into their textbooks to find out what is happening in each phase and how the text organizes the phases of mitosis.

Assessment:

1. Students are to make a model of a cell which is in the process of mitosis and cell division. They should draw on their paper the border of a cell which is dividing. These need to be big enough so that the pipe cleaners can be put inside. There needs to be a cell border for interphase, prophase (perhaps one for early and late prophase), metaphase, a partially dividing cell for anaphase, a nearly totally divided cell for telophase, and two new cells for the daughter cells.

2. Students will take the pipe cleaners and place them in the "cells". They should arrange four "chromosomes" properly in the various phases of mitosis. The pipe cleaners may be taped or glued on the paper and a description written which describes the events occurring within the cell. The pipe cleaners may be manipulated and each phase described to the teacher. Students may work in groups of four and only one student from each group would be tested to save time evaluating the mitosis demonstration.

3. The teacher should determine the grading method, points or letter grade, but a recommended method would be: 5 for all the phases demonstrated exemplary in proper order with a detailed description of each. 4 for correct demonstration of phases and clear description. 3 for a generally correct model but lacking some clarity and detail. 2 for a partial demonstration, perhaps the phases are out of order or improperly shown and the description is incoherent. 1 for an incorrect demonstration of model and explanation.

Other notes:

1. For a multicultural emphasis on teaching, students can observe that different organisms have cells which look very similar. Different races and nationalities of people must have cells which are not distinguishable from each other.

2. It may not be necessary to use a visible pipe cleaner model to better understand mitosis, but when teaching meiosis the model is very good to demonstrate crossing over and variable gamete formation as well as differences from mitosis.

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Cell Size and Division or How Big Would You Want To Be If You Were A Cell

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Objectives:

1. For all grades: to illustrate the usefulness of models to represent things which are too small (cells or molecules) or too large in science.

2. For primary grades: to learn to measure with a ruler, to cut a cube, and determine smaller particles react faster than larger particles.

3. For middle grades: to determine surface area and volume of a cube in addition to the above.

4. For upper grades: to determine the surface area to volume ratio and relate this to cell size, to determine why cells divide and 1-3 above.

Materials:

2500 ml 2% agar solution (sufficient for 15-20 set-ups or pairs)
a cake pan
phenolphthalein powder
1 250 ml beaker or cup
50 ml .4% NaOH solution
a metric ruler, stirrer or spoon, plastic knife, and paper towels

Strategy:

1.Advance Preparation:
Mix enough agar powder in boiling water to make a 2% agar solution. Use enough water to fill a cake pan to a depth of 3 cm (approximately 2500 ml). Stir until all the powder is dissolved. As the agar cools, add 1 g of phenolphthalein (if solid is unavailable, add several ml of liquid phenolphthalein indicator) per liter of solution and stir thoroughly. If the color is pink, add dilute acid drop by drop until the solution turns colorless. Pour the mixture into the cake pan to solidify. This will provide the agar for the model of the cells. If agar is unavailable, substitute potatoes, but then razor blades must be used and a dye found which will penetrate the potato in a short time.

2. Discuss models and their importance with the class. In this activity we will use agar blocks to represent cells.

3. Give the students a 6x3x3 cm block of agar cut from the cake pan, a plastic knife, and metric ruler. Ask them to cut three separate cubes 1x1x1, 2x2x2, and 3x3x3 cm from the block.

4. Ask the students, "If you were a cell which cell would you rather be (small, medium, or large) and why?" Write this down.

5. Ask the students to place the cubes into the beaker. Then the teacher pours

the NaOH into the beaker to just cover the cubes. (CAUTION: Sodium hydroxide is caustic and can burn the skin and eyes.)

6. The cubes should remain in the solution for 10 minutes. They should be stirred occasionally with the spoon. When the NaOH comes into contact with the agar blocks, the blocks and perhaps the solution will turn a pink color. The students enjoy this.

7. Depending on the grade level, students should be given a task to do while the cubes are "soaking". Primary grades may be asked if this were a cell, what type of things might move into it. Older students may be asked the same as well as to explain diffusion since this is what is happening. They should also be asked to set up a data table in which they determine the surface area, volume, and surface area to volume ratio for each cube.

8. After 10 minutes the cubes are taken out of the beaker with a spoon and dried off with a paper towel. The students should cut the cubes in half and measure the distance from the outer edge inward that has turned pink and record this.

9. Students will discover that the distance that the solution travelled in each cube is the same (5 mm). There is a pink border around the 2x2x2 cm and 3x3x3 cm cube, but the 1x1x1 cm cube is pink throughout. Ask if the pink represented food, water or something else needed by the cell to survive, which "cell" got the needed substance distributed to all its parts. They should see that the smallest cell is most efficient since it is pink throughout.

10. Mathematically, students should observe that the smallest cube has the largest surface area to volume ratio (SA:VOL). Therefore this illustrates that a large SA:VOL promotes better efficiency in moving things into and out of cells and thus survival. This can also be related to smaller particles reacting faster than larger particles in chemical reactions (i.e. Granular sugar dissolves easier than sugar cubes.)

Assessment:

Students can be asked which type cell they think would have a better chance for survival, one which is 1x1x1 cm or one which is .1x.1x.1 cm. They need to justify their response. 5 points for a proper mathematical as well as written explanation. 4 points for an explanation which is a little unclear. 3 points for a proper explanation but improper or no math. 2 points for an unclear explanation but shows thought. 1 point for an honest attempt.

Sources:

Adapted from **Biological Sciences: An Ecological Approach**. Kendall Hunt. 1987

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The Effects Of Osmotic Balance And Imbalance In Living Cells

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Objectives:

1. Students will review the processes of diffusion and osmosis.
2. Students will prepare a wet mount of an elodea leaf in tap water and a wet mount of an elodea leaf in salt water for microscopic observation.
3. Students will observe and diagram cells of both wet mounts.
4. Students will distinguish between osmotic balance and osmotic imbalance in elodea leaf cells.

Materials needed:

microscope	cover slips	medicine droppers
microscope slides	elodea (water plant)	water
6% salt solution		

Strategy:

Begin the lesson by either reviewing the definition of diffusion and osmosis and/or by discussing the previous lab on the same topic.

Diffusion - the gradual movement (spreading out) of molecules from an area of greater (higher) concentration to an area of lesser (lower) concentration.
Osmosis - the movement of water and dissolved materials from an area of greater (higher) concentration to an area of lesser (lower) concentration through a semi-permeable membrane.
Divide the activity into Part A, osmotic balance, and Part B, osmotic imbalance. Students may work individually or in pairs.

Part A: Osmotic Balance

1. Prepare a wet mount of an elodea leaf in tap water for microscopic observation.
2. Observe the cells of an elodea leaf under low and then high power of your microscope. Locate a single cell along the leaf edge. Observe the location of the chloroplasts in relation to the cell wall.
3. Save this slide for Part B.

Part B: Osmotic Imbalance

1. Prepare a second wet mount using another elodea leaf. Use 6% salt solution instead of tap water.
2. Let the wet mount stand for two to three minutes and then observe cells of this leaf under high (dry) power.
3. Place the tap water slide on the microscope stage next to the saltwater slide.
4. Compare the saltwater leaf to the tap water leaf by simply switching back and forth from one slide to the other while viewing under high power.
5. Check the saltwater slide carefully. Observe the location of the

chloroplasts in relation to the cell wall when viewed under high power.

6. Diagram, on a sheet of unlined paper, a single cell from each slide. Label the cell wall, plasma membrane and chloroplast in both cells.

Conclusion:

When living cells are placed into any environment where there is a higher water concentration inside the cell compared to outside the cell, water loss called plasmolysis, can result. This may be harmful to the cell. However, most cells live in an environment where the movement of water in and out of the cell is equal. Therefore the cell is in "osmotic balance" and there are no harmful effects to the cell.

Evaluation:

Use the following information to help you answer these questions:
(a) Elodea cells normally contain about 1% salt and 99% water.
(b) Tap water normally contains about 1% salt and 99% water.
(c) Salt solution contains 6% salt and 94% water.

1. What observable change is seen in the cells showing an osmotic imbalance?
   Explain your answer.
2. What observable change is seen in the cells showing an osmotic balance?
   Explain your answer.
3. In the wet mount using salt solution, where was the higher concentration of water located at the start of this experiment? Where was the lower concentration?
4. According to osmosis, water moves from areas of high concentration to areas of low concentration. In which direction should water move in the cell of Part B? What evidence do you observe to support this?
5. What term describes the condition of a cell when it loses water?

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Cells, The Structural and Functional Units of Life

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Objective:

In this exercise you will

A. Have a working knowledge of the vocabulary applicable to plant and animal cells and the organelles within each cell.
B. Observe the general structure and organelles of cork cells, plant cells and animal cells using iodine and methylene blue.
C. Apply your knowledge of lab equipment, chemicals and operations of the microscope.
D. Discuss the similarities and structurally diverse differences between eukaryotic and prokaryotic cells.
E. Observe the structure of:

1. ELODEA 2. ONION 3. CHEEK 4. CORK

(Draw, label and identify whether plant or animal; prokaryotic or eukaryotic.)

F. Identify major differences between plant and animal cells.
G. Student will be able to list principle functions of each cellular organelle.
H. Students will be able to identify and state the characteristic that is unique to eukaryotic cells, that is, the compartmentation; a sequestering of functional metabolic machinery.
I. Students will have an understanding of the structure and functions of the cells.
J. Be able to identify cells by size and shape whether unicellular, multicellular, plant or animal.

Materials:

Compound Microscope	Cork Stopper
Scalpel or Single-edged razor blade	Onions
Cover Slip and Slides	Elodea
Flat Toothpicks	Cheek cells (taken in class)
Forceps	Lugol's Iodine
Paper towels; Kleenex	Methylene Blue and Water

Recommended Strategies:

Have the students prepare work stations with

1) paper towels
2) microscope
3) gather materials from stations set up in class room necessary for lab.
4) use alcohol for cleaning lab areas after experiment. Each table will have an onion wedge, a stem of elodea and a cork stopper.

CAUTION STUDENTS ON:

1. Use of iodine and methylene blue because of damage to clothing and discoloring of skin.
2. Iodine inhaled can be hazardous to your health.
3. Use of sharp objects: take necessary precautions.

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A Hands-On Approach to Teaching the DNA Structure and FUNCTION

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Objective:

To understand the structure of DNA and the way in which DNA duplicates by building simple models of DNA and its components.

Apparatus Needed:

Large and small paper clips, 5 cm lengths of colored pipe cleaners, styrofoam blocks.

Recommended Strategy:

1. Suggested use of materials:
   Large paper clip to represent deoxyribose sugar
   Small paper clip to represent phosphate group
   Yellow pipe cleaner - adenine base
   White pipe cleaner - thymine base
   Red pipe cleaner - guanine base
   Orange pipe cleaner - cytosine base

2. To form a nucleotide, hook a large paper clip to a small paper clip. Then take a short piece of pipe cleaner and fasten it to the center of the large paper clip. Remember what each of these represents.

3. Put half of your nucleotides to one side (two of each color). These will be used later as your free nucleotides. Line up the remaining nucleotides in one row and write down their order, then determine what the other side of the ladder would have to be to match. Do this about three times to familarize yourself with the order in which the bases pair.

4. Make a flat model of DNA, using the nucleotides you have before you, hook half the clips together (using one of each color), making sure the large and small clips alternate to form one side of the ladder. Using the four remaining nucleotides, match the bases in proper order, hook the pipe cleaners together and then hook the clips together to form the sides.

5. To show replication, unhook the pipe cleaner bases from each other to form two chains. Now using your free nucleotides that you put to

the side, match them in their proper order and fasten the bases and paper clips together to form two DNA molecules.

6. To make a three-D model, use two pieces of styrofoam and one of the flat DNA models. Straighten out the two paper clips at each end and press them into the styrofoam strips. Hold a styrofoam strip in each hand, stretch out the model, and twist slightly to give a spiral staircase effect.

Part II: mRNA STRUCTURE and TRANSCRIPTION

Objective

To use the DNA model to build a model of mRNA which will demonstrate its structure and the way it is formed by transcription.

Apparatus Needed:

Models from Part 1, the same materials, plus large colored paper clips to represent ribose, and green pipe cleaners to represent the uracil base.

Recommended Strategy:

1. Use the materials to form nucleotides of mRNA, at least two of each of the four bases.

2. Use the flat model of DNA from Part 1 and your mRNA nucleotides to demonstrate transcription. Unhook your flat molecule at its bases. Match the mRNA nucleotides in their proper order (keep in mind that thymine is replaced by uracil).

Evaluation

For a follow up assignment write a report describing the structures of DNA and mRNA and the processes of replication and transcription.

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PLANT AND ANIMAL CELLS

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OBJECTIVES:

1. Being able to identify parts of plant and animal cells and to describe function(s) of each part.

2. Being able to distinguish between plant and animal cells.

MATERIALS:

Solution of sodium borate (see attached)
Solution of polyvinyl alcohol (see attached)
Zip-lock transparent sandwich bag for each pupil
Modeling clay
Saran Wrap
Lima bean seeds - dyed
Dry rice - dyed
Peppercorn
Packing material bubbles
Overhead projector
Transparencies
Containers - McDonald`s hamburger boxes and petri dishes

STRATEGIES:

1. Abstract to Concrete
   a. Develop vocabulary and describe functions associated with each organelle by:
      (1) Listing the following on chalkboard and discussing functions:
      plasma membrane cytoplasm nucleus cell wall
      vacuole mitochondria ribosomes chloroplasts
      nuclear membrane
      (2) Use overhead projector and transparencies to show plant and animal cells to reinforce structure name and function of each part.
   b. Construct models of plant cell and animal cell by adding mixture of polyvinyl and sodium borate into sandwich bags. To this mixture add organelles (nucleus-clay nuclear membrane-saran wrap vacuoles-bubbles mitochondria-dyed dry rice ribosomes-peppercorns embedded in thin rolls of clay) (cell wall and chloroplasts-hamburger container and dyed lima beans added to plant cell.
   c. Review with worksheet that requires students to distinguish between plant and animal cell and describe functions of each organelle.
2. Concrete to Abstract
   a. Worksheet used as guide in constructing models of plant and animal cell.

b. Names and functions of each organelle discussed as each item is added.

c. Review structures and corresponding functions through use of chalkboard and overhead projector.

2

REQUIRED MIXTURES

1 liter-polyvinyl alcohol mixture

l. Using magnetic automatic stirring hot plate and large beaker, heat l liter of distilled water to boiling.

2. 40 grams of polyvinyl alcohol powder added gradually (approximately 2 or 3 grams at a time) until dissolved. Continue adding polyvinyl powder until 40 grams have been dissolved in l liter of distilled water.

100 milliliters-sodium borate - Mix 4 grams of sodium borate powder to 100 ml of tap water in container.

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Eartha Sherrill - Daniel Hale Williams School

People Are Like Peas in a Pod

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Objective(s):

The objectives of these activities are:

1. To observe and appreciate the diversity of individuals within a population.

2. To promote student understanding of how dominant traits, recessive traits, genotypes, and phenotypes help produce variation in a population.

3. To demonstrate how to construct a Punnett Square.

These activities are designed for grades 5 - 8.

Materials Needed:

Activity One
- 1 dozen intact fresh pea pods
- a roll of paper towels

Activity Two
Enough materials for groups of two.
- styrofoam cups
- one-half cup of black-eyed peas
- plastic or metal tray
- metric ruler
- graph paper
- Science notebook

Activity Three
- 2 pieces of 8-1/2" by 11" black or dark colored construction paper cut into 4 parts, each about 2 1/2" by 8 1/2"
- 2 pieces of clear transparency film cut into four parts

Strategies:

Activity One
1. Write the words population, species, and variation on the blackboard.
2. One member from each group will obtain a pea pod.
3. Have each group examine a pod to observe the variations in pea size. When students open the pods, they will notice that the peas near the center are larger. Why? Are the peas constricted? This can lead to

a discussion of heredity and environment.

4. Relate the terms species, population, and variation to the pea pods.

Activity Two

1. Have students form groups of two and have one member from each group get the supplies.
2. Point out that the cup of peas is the group's sample population and that they are looking for variations within that sample.
3. Ask students to pour the peas onto the tray so they can see all the peas at once. Each group should look for ways the peas are similar or different.
4. Tell each group to choose three differences (variables) including one that can be measured with the ruler.
5. Monitor the class as they decide which characteristics of peas they will select. Those who can't find any characteristics other than color, texture, or size might need a little prodding. Ask those students a question such as, "What other differences do you see?"
6. Taking one variable at a time, students should sort their peas on the tray, then write the variable and record the number of peas showing that characteristic in their notebook.
7. Students will take the results for each variable and plot the number of peas on the graph paper. (A bar graph works well.) Place a model on the chalkboard as an example.
8. Have those students who finish the sorting, classifying, and plotting before others, compute the data percentages and record them in their notebook.
9. When the class has finished the assignment, have each group share their results. Write the results on the chalkboard and discuss the similarities and differences between the findings of each group. Some questions to consider for discussion: Why are some peas wrinkled or small? Why are there differences between samples?

Activity Three

1. Discuss and write the terms dominant trait, recessive trait, genotype, and phenotype on the blackboard. Have students write the definition for each in their notebook.
2. Place students in groups of two and have one member from each group get the materials.
3. Explain to students that they have two pieces of dark construction paper and two pieces of clear plastic. Say "The dark paper represents a dominant gene and the clear plastic represents a recessive gene." In the activity, use the words "dark" or "clear" to describe the phenotype and the letters "D" for dominant and "d" for recessive to describe the genotype.
4. Write the following instructions on the chalkboard.

   Describe the genotype and phenotype.

   1. Place one dark strip on top of the other dark strip. Result?
   2. Place one dark strip on top of one clear strip. Result?
   3. Place one clear strip on top of one dark strip. Result?
   4. Place one clear strip over the other clear strip. Result?

5. Discuss and demonstrate the results on a Punnett Square. Then show students how to show inheritance through three generations.
6. Provide students with a list of dominant genes in humans. Working in pairs, students will select one human trait and demonstrate three

generations on a Punnett Square.

7. Individual groups will write their results on the chalkboard. Then each group will discuss the accuracy of their results.

Performance Assessment:

Students will write a paragraph explaining how inheritance of dominant and recessive genes helps produce variation in a population.

Conclusions:

Dominant and recessive genes can contribute to variation in a species. Variation is necessary for the survival of a species.

References:

Super Science Activities. Palo Alto, CA: Dale Seymour Publications, 1988.

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Mathematics/Physics

DNA Extraction with Kitchen Chemistry

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Objective(s):

Students will learn that you can extract DNA from various foods that are found in your refrigerator. This lesson is designed for middle school grades.

Materials Needed:

Dry split peas, Blender (optional), Dish detergent, Toothpicks, Meat tenderizer, Small Glass Containers, Alcohol, Onions, Yeast, Brocolli, Raw chicken liver, Strainer

Strategy:

Students will follow these procedures for DNA Extraction:

Step 1.

1. Measure out 1 cup of water, ¼ cup of peas, and ¼ tsp. of salt. Stir until salt is dissolved. Leave the peas in water until softened. (I would soak the peas overnight to soften them.)
2. Put the peas and the salt water in the blender and chop for just a couple seconds. You may use a fork to squash the peas. The mixture should be lumpy, containing small pieces of peas. Too much blending will break up the DNA and make it too hard to see.
3. Gently mix the peas and water from the blender with a few drops of soap in a new container.

Step 2.

1. Put the pea mixture in the strainer.
2. Filter about 1/3 cup of the liquid into a small glass container.
3. Wet the end of a toothpick and dip it into the meat tenderizer.
4. Put the end with the enzymes in the cell mixture and gently stir.

Step 3.

1. Slowly pour in an equal amount of alcohol (about 1/3 cup)
2. The alcohol will form a layer on top of the cell debris.
3. Watch carefully as the DNA precipitates through the alcohol. The DNA is clear. Small bubbles will attach to the strands as they migrate up through the alcohol. Use the toothpick to gently stir the alcohol layer. Notice how those strands move like snot. The snotty substance is the DNA.

Performance Assessment:

Now that you have extracted DNA from peas, think about each step of the procedure and why it works.

How did each of the ingredients in the demonstration help extract DNA from the other parts of the cell?

What part of cells would be most affected by soap?

What is it in meat tenderizer that breaks down meat?

Alcohol and salt: Why does only the DNA, and not the other parts of the cell, rise to the top after addition of alcohol?

References:

DNA Extraction with Kitchen Chemistry. The Natural History of Genes. University of Utah, Salt Lake City, UT

Biology/Chemistry

Monstrous Mutations

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Objective(s):

Middle School to High School

- To understand and observe mutations.
- To recognize and adapt to mutations
- To observe how mutations effect survival skills

Materials Needed:

Nine dry peanuts in shell (per group of three students)
Blanket for the peanuts
Table or desk
One cup (per group of three students)
15 plastic knives
Six pairs of goggles
Cotton
Stop watch
Large roll of duct tape or masking tape
String
Paper bag containing the letters A through H on slips of paper

Strategy:

1. Students should form groups of threes. Each student will simulate an animal that can only digest peanuts as its food source.
2. Unfortunately, random mutations have produced some unusual characteristics in recent offspring. Each group will find out what mutation they represent by selecting a letter from the paper bag the teacher has provided.
3. The letter drawn will correspond to the characteristics listed in Chart 1. This letter will also represent the letter of each group's home location and storage cup.

Chart 1

Letter drawn by groups	Characteristic produced by mutation
A	Long fingernails (produced by plastic knives taped to fingers with tape)

B	No fingers (produced by taping each hand closed)
C	Lack of peripheral vision (produced by putting on goggles and stuffing cotton in the sides to prevent viewing from the side)
D	Hands fused together in front of body (produced by placing hands together in front of body and taping them together)
E	Feet and ankles fused together (produced by taping the ankles tightly together with tape)
F	No arms (produced y taping the arms down to the side of the body with tape)
G	Arms fused together behind the back at the wrists (produced by placing arms behind the back and taping tightly at the wrists)
H	Blind (produced by using goggles taped over securely with tape)

Each group should attain the proper materials and prepare itself to represent the characteristic produced by the letter of the mutation selected from the paper bag.

5. Each group should begin the activity at the specified location in Figure A. The goals of each group are to:

A. Gather the food (nine peanuts per group)

B. Store the food for later use (place the nine peanuts in your letter-designated container).

C. Retrieve the food at a later time (remove the nine peanuts from the container and return with the peanuts to the home location).

D. Process and consume the food (remove the peanuts from the nine shells and consume these peanuts).

6. To begin the activity, each group should position itself at its specified home location. The teacher will start the stop watch and each group will begin with food gathering. Group members should proceed to the blanket containing the peanuts and gather nine peanuts per group. These nine peanuts should then be transported to a container. The three group members should return to their home location. At this point, the group will proceed back to the plastic container to retrieve its food. Once the group has removed all nine peanuts, it will return to the home location. The

group will open the peanut shells and remove the contents. Each group member will consume the contents of three of the peanut shells at the completion of this process, the amount of time required to achieve this will be recorded.

7. Each group will continue until the peanuts have been consumed and time has been recorded.

8. The teacher will write the times required for each group to complete the process on the chalkboard (a bar graph can be made).

Performance Assessment:

Successful completion of activity

References:

Hands on General Science Activities With Real-life Applications by Pam Walker and Elaine Wood

Biology/Chemistry

DNA/Genetics

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Objective(s):

grades K-9

understanding DNA, which is the genetic material for every person and every other living thing

Materials Needed:

Materials are listed for groups of 2-4.

Project 1. - 1. Large grape 2. Sandwich size ziplock bag 3. Lemon Jello

Project 2. - 1. Masking tape 2. 2 pennies 3. Marking pen 4. Pencil 5. Ruler 6. Sheet of typing paper 7. Small hand towel

Project 3. - 1. ZOOB

Project 4. - 1. Scissors 2. Model of double helix

Project 5. - 1. Sculpt hubs

Strategy:

Project 1

1. Mix Jello ingredients.
2. Let Jello cool at room temperature.
3. Pour the Jello into the ziplock bag.
4. Seal the ziplock bag.
5. Place the ziplock bag into the refrigerator.
6. Let it chill for about 3 to 4 hours in the refrigerator.
7. Remove the Jello from the refrigerator and open the bag.
8. Use a finger to insert the large grape into the center.
9. Reseal the bag and then put the bag on a flat surface.
10. Observe its shape as it is now.
11. Gently squeeze the bag.
12. Observe as you squeeze the bag.

Project 2

1. Place one small piece of tape on the front and back of each penny.
2. Use the pen to write a capital E on one side of each penny and a lowercase e on the other side.
3. Use the pencil, ruler, and paper to prepare a chart.
4. Stretch the towel out on a table.
5. Hold both coins in your hands and shake them back and forth several times, then toss the coins together over the towel.
6. Put an X on your chart under "Trail 1" and next to the letter combination showing coins.
7. Toss the coins three more times, recording each letter combination under Trail 1.
8. Repeat steps 5 through 6 two more times, recording the results of each trial.

Project 3

1. Sort out the different pieces.
2. Connect the different pieces to form a double helix.

Project 4

1. Cut out the four pages from the book.
2. Looking at the inside of the model score along all score lines.
3. Cut out precisely and fold into hill and valley.
4. Fold as it is indicated and crease firmly.
5. Glue all 8 pieces together using the letters A through G in alphabetical order to make a single large net.
6. Crease paper and check how the paper folds to form the double helix.
7. Start gluing with flap number 1.
8. Work in numerical order from 1 to 13 until the double helix is completed.

Performance Assessment:

Students will be assessed on the following items:

- journal writing entries
- examples of cells
- model of double helix and nucleotide models
- oral and written presentation of their group report

References:

DNA by Sonja Broomes, 1998

Amazing schemes within Your Genes by Dr. Fran Balkwill. Carolrhoda Books, Inc.1993

Understanding DNA and Gene Cloning A Guide for the Curious by Karl Drlica

DNA The Marvellous Molecule by Borin Van Loon. Targuin Publications. 1990.

DNA and the Creation of New Life. The Arco How it Works Series.

Groovy DNA Beads

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Objective:
This lesson is designed for 7th - 10th graders. The main objective of this mini-teach is provide students with a hands-on experience matching DNA nitrogenous base pairs, arranging nucleotides into codons, and visualizing the size of a single gene.

Materials Needed:
(For Pairs of Students)
--Plastic beads (the type which you can string), approximately 1,000. You should have 6 **distinctly different** colors.
--String (3 strings per group), approximately 2.5 feet long.
--Plastic baggies (1 for each group).

Strategy:
Note: place at least 42 beads in each bag, making sure that you've given each pair of students a wide variety of all 6 colors. You must give out all 1,000 of the beads in the baggies. Place the three strings in the baggie. Although I've used green, pink, blue, yellow, orange and purple in this write-up, you aren't limited to these colors. But you need to choose the colors which will represent each nitrogenous base.

A **nucleotide** of DNA is made of three parts: a nitrogenous base (the part we're going to work on); a 5-carbon sugar called **deoxyribose**; and a phosphate group. There are four nitrogenous bases of DNA **A, G, C, T** (Adenine, Guanine, Cytosine and Thymine).

1) The beads in your plastic bag represent one of the four nitrogenous bases. For now, set aside the orange and purple beads.
2) Green represents A; pink represents G; blue represents C; yellow represents T. So each color represents a **nitrogenous base** of DNA. Write the colors in the space below:

A = _____________ G = _____________ C = _____________ T = ______________

3) Take both of the strings out of your bag and tie a knot in one end of the string. The knot should be secure, but not tight.
4) In a reasonably random order (in other words, don't string AGCTAGCT), string 21 beads on one of your strings. In the space below, write the nitrogenous bases you have strung together.

-- --
(string #1)

DNA stands for **deoxyribonucleic acid** and is unique in a few ways: A, G, C, T (adenine, guanine, cytosine and thymine) are the nitrogenous bases; it is inside the nucleus; it is always double stranded. Now that you have made one strand of DNA, you are going to make its **complementary** strand. In order to make a complementary strand of DNA, you need to know that green and yellow (adenine and thymine) are **base pairs**; blue and pink are **base pairs** (cytosine and guanine).

5) In the space below, write the color of the other part of the nitrogenous base pair. The first one is written for you.

A = green ----> T = yellow
T = yellow ----> A = _______
G = pink ----> C = _________
C = blue ----> G = _________

6) On the first line, again write the nitrogenous bases you strung together. On the second line, write the other part of the nitrogenous base pair. In other words, if you strung together ACCGTTA on the first line, then on the second line you'd write TGGCAAT. This is called **base pairing** because the nitrogenous bases A and T (adenine and thymine) are paired, as are C and G (cytosine and guanine).

-- --
(string #1)

-- --
(string #2)

7) Now that you've written the complementary strand of DNA, use the other string in your bag to string together the beads that represent each nitrogenous base. Put a loose knot at the other ends of both strings.
8) Hold both strings at both ends. Make sure that the **base pairs** are touching. Gently twist the two strands to the right. You've created a **double helix.**

MAKING A COMPLEMENTARY STRAND OF RNA

RNA stands for **ribonucleic acid.** RNA is similar to DNA with two differences: the 5-carbon sugar is a ribose instead of deoxyribose; and RNA does not have thymine, instead RNA has **uracil**. So, green is paired with purple (adenine with uracil); yellow is paired with green (thymine in DNA is paired with adenine in RNA); and pink is still paired with blue (guanine with cytosine).

1) You'll now use the purple beads which will represent U (uracil).
2) In the space below, write the color of the other part of the nitrogenous base pair. The first one is written for you.

DNA	RNA
A = green -------->	U = purple
G = pink ------>	C = _________
C = blue ------>	G = _________
T = yellow ------>	A = _________

3) On the first line below, again write the nitrogenous bases (string #1) of DNA. On the second line, write the corresponding RNA strand. So that if you string together ACCGTTA, you'd write UGGCAAU.

-- --
(DNA string #1)

-- --
(RNA string #1)

4) String the beads which represent the **nitrogenous bases** of RNA.

CODONS

DNA **transcribed** into RNA will (eventually) make proteins. Proteins are important because they control biochemical pathways within the cell, direct the making of essential compounds like lipids, carbohydrates and nucleotides, and are responsible for the structure and movement of the cell. A protein "begins" as a sequence of **codons**. Codons are 3 nucleotides of RNA. So that if you had UGGCAAUCG --> UGG is a codon; CAA is another codon; UCG is the third codon in this string of RNA.

1) Again write down the RNA strand (RNA string #1) you've made and put a slash between each codon.

-- --
(RNA string #1)

2) Separate the codons on your string by making a 1/4" - 1/2" space in between the beads.
3) How many codons did you get? ________________

THE GREAT LEAP FORWARD

Now that we've been working with nitrogenous bases, let's take a leap into chromosomes.

1) Using all three strings, string all of the beads in the baggie (in random order).
2) Put a loose knot on both ends of the strings.
3) Have the students hold each string horizontally. They should stand next to one another with the ends of the strings touching. They are representing one strand of the double-stranded DNA.
4) We have approximately 75,000 to 100,000 genes in human cells. A single human gene has about 10,000 nitrogenous base pairs. If the class holds only 1,000 base pairs, how many more classes and how many more beads would we need in order to represent a single human gene? __________ and __________
5) EXTRAPOLATION: how is it possible to get all that genetic information inside one chromosome? (answer: genes portions of DNA which is **coiled** inside a chromosome)

Performance Assessment:
Students will be able to:
- identify the four nitrogenous bases of DNA;
- identify the two base pairs of DNA;
- describe the shape of a DNA strand;
- identify the four nitrogenous bases of RNA;
- identify the two base pairs of RNA/DNA;
- explain the size of a codon;
- explain and visualize the size and number of human gene(s).

Conclusion:
The concept of DNA/RNA base pairing and formation of codons is difficult for students to understand and visualize. This activity is inexpensive and easy.

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Wearing My Genes: Basic Principles of Heredity

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Objectives:

This lesson is for special education 5-8th grades. Students will be able to:

1. Explain what heredity is.
2. Distinguish the difference between the dominant and recessive genes.
3. Explain the difference between phenotype and genotype.
4. Predict the results of a monohybrid genetic cross using the Punnett Square.

Materials Needed:

1. Punnett square (drawn on 8 1/2" X 11 sheet of paper)
2. mirrors
3. marshmallows (marshmallow stars have different shapes and colors)
4. construction paper

Strategy:

An explanation of what heredity is, with student questions and responses. The students, grouped in two's, will be given a drawing of a pair of jeans, on the pants pocket the students will find their sex chromosomes, either an XX=female or XY=male. Students will be given an explanation of what the sex chromosomes are. Students are then given a mirror, taking a look at themselves, the students explain what they see. The students will see that everyone has different or similar traits that are passed from their parents.

Activities

1. Using a peek-a-boo writing paper, students will write a description of what they see.

2. Given a worksheet titled "Designer Genes", students will do the following activities: An explanation of what a dominant and recessive gene is given in the directions. (Ref. **The Human Body.**) For example, some of the traits discussed on the worksheet are:

   a. Examine the eye color (dark is dominant; blue is recessive)
   b. Look for dimples (presence of dimple is dominant; absence is recessive).
   c. Look for attached or unattached earlobes (unattached is dominant; attached is recessive).
   d. Ability to roll tongue into a u-shape (ability is dominant; inability is recessive).

3. The students will pick one of the above traits and write a possible genotype for the characteristics they can observe (called phenotype). For instance, if a person can roll her tongue, she could have either a

RR genotype (the presence of two dominant genes) or **Rr** (the presence of one dominant and one recessive gene called **hybrid**).

4. Students will then use a Punnett square to write their findings. Draw a square making 4 boxes. Working in pairs, one student will put his genotype at the top of the box. The other student will put her genotype on the side of the box. The letters at the top and left of the square represent the genotypes.

	D	D
D		
d		

   a. After the crossing of each genotype from the female on the side of the square and the male on the top, the students will then have their possible genotypes and phenotypes of the offspring.

	D	D
D	DD	DD
d	Dd	Dd

5. As a manipulative, use marshmallows of varied sizes and colors to represent the genotypes of the parents and the possible genotypes of the offspring.

   a. Students will use the same characteristic as in step #3. Have students choose marshmallows which will represent the dominant and recessive genes.

   b. Using the 4 boxes, the students will place their marshmallows in the appropriate boxes according to the genotypes.

6. Next, give students a copy of a **karyotype**. A karyotype is a picture of the 23 pairs of human chromosomes. In order to prepare, you should first label each chromosome pair, one with a letter (a for example) and the other half of the pair with a number (1 for example). Students will cut the x's and will match appropriate pairs of chromosomes, starting with 1a, 2b, etc, and then paste or tape the pairs on construction paper.

Performance Assessment:

Given a puzzle vocabulary the students will try to put together the meaning of the vocabulary words:

1. heredity
2. gene
3. genotype
4. phenotype
5. dominant gene
6. recessive gene
7. offspring
8. Punnett Square
9. hybrid

Students will construct a Punnett square, and will explain how we inherit traits.

Conclusion:

From these activities the students will learn:
- what dominant and recessive genes are;
- how to write a genotype and a phenotype;
- distinguish between the genotype and the phenotype.

The students will have a better understanding of what heredity is.

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Inheritance in Maize (Indian Corn)

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Objectives:

To calculate the phenotypic ratios for some monohybrid and dihybrid crosses.

To determine the genotypes of parents from the phenotypic ratios of their offspring.

Materials needed:

mutant corn ears
pencil and paper
straight pins
calculators

Background:

Commercially available corn represent crosses between various parental genotypes. Results of a cross between pure-breeding purple kernel corn and pure-breeding yellow kernel corn produces offspring which are all purple (demonstrating dominance). A cross between two of these offspring produce 3/4 purple and 1/4 yellow kernel corn. These are the commercially available ears.

Strategy:

Obtain ears of corn representing offspring of crosses from various mutant and wild type plants from a biological supply company. Divide the class into groups of two or three. Give each group an ear of corn. Place a pin at one end of a row of kernels to mark your starting row. Using a pencil to point to the kernels, one partner should indicate the phenotype of each kernel while the other partner keeps a tally.

Each ear of corn is labeled with a code.

Conclusions:

1. For each ear of corn, calculate and record the ratio of the phenotypes. Divide the number of purple by the number of yellow. Also, divide the number of starchy by the number of sweet.

2. From the data, determine the genotypes of the parents in each cross.

3. How do the actual offspring phenotype ratios compare with the expected ratios?

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Traits

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Objective:

Grade level 6

Students will understand that certain physical traits are inherited from their parents through the genes.

Materials needed:

posters, chalkboard, collage, and activity handout

Strategy:

Review with the students Mendel's experiments with the pea plant.

Bring in posters of animals and their offspring. Students will recognize their likenesses and differences.

Students will turn toward their partners and observe their physical traits such as eyes, hair, cheekbones etc.

Demonstrate to the students the Punnet Square with the use of the chalkboard.

Discuss the game the "Happy Gologg".

Students will complete the activity sheet using the mirrors in which they will check their own physical traits for their own recessive and dominant traits.

Conclusion:

This lesson will conclude the unit on determining traits in an organism.

References:

Science: Teacher's Edition - 6, published by Addison-Wesley, 1989, source for the game "Happy Gologg"

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Principles of Heredity

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Objectives:

To learn the role of genes in inheritance
To understand the idea of dominant and recessive genes
To understand the role of chance in the inheritance of traits

Apparatus needed:

craft sticks or tongue depressors, construction paper
colored markers, self-adhesive labels, 5/16" x 1/2"
2 transparencies, overhead projector

Recommended strategy:

The labels are applied to the craft sticks, which will represent chromosomes, in different positions for each trait. The labels represent genes. Seven traits are being considered: stem length, flower position, seed shape, seed color, seed coat color, pod shape and pod color. Different colored labels are used to represent the various traits. There should be a pair of sticks for each dominant and each recessive trait. A capital letter is used for the dominant trait, and a lower case letter for the recessive trait.

Make a key for the traits for a garden pea plant, and give one to each student. Make a transparency diagramming meiosis using letters in lieu of sex cells. Make another transparency of a Punnet Square, diagramming the cross of the F1 gametes from the first transparency. Have a vocabulary sheet with the following information and definitions: Gregor Mendel, dominant character, recessive character, alleles, homozyous, heterozyous, hybrid, genotype, phenotype, Law of Dominance, Punnet Square, F1, F2, trait, gene and heredity.

Begin the lesson by showing pictures of animals from the same litter and ask about their similarities and differences. Ask if they have noticed any similarities and differences among family members. Lead into the concepts of inheritance and heredity.

Lead into the fact that the study of heredity is called genetics. Pass out chromosome sticks and the nucleus cut from construction paper. Review meiosis and ask what the sticks and labels are representative of based on our study of meiosis. Use the chromosome models to lead into the concepts of: chromosome pairs, genes, dominant trait, recessive trait, heterozyous, genotype and phenotype. Discuss the meanings of the various word roots and go over the definitions on the vocabulary sheet. When discussing each concept, use the board to illustrate each. The students should also be moving and grouping their chromosome/gene models in the "nucleus" to correspond with each concept. Ask the class to give the genotype and phenotype of their various combinations.

Introduce to the Punnett Square by randomly shuffling two homologous sets of chromosome sticks and asking them what combinations they think might occur when you separate into pairs. Discuss chance and ask what games of chance with which they are familiar. Tell them that the Punnett Square is a method of determining the probability of certain combinations.

Use the transparency with letters for gametes and discuss what would be the result of a cross between F1 offspring. Then introduce the transparency with the Punnett Square and diagram results.

Now, on their own have create various gene combinations with their chromosome models. Have them describe the genotype and phenotype. Give examples of various F1 crosses to use with a Punnett Square. Also, have them list traits that they have in common with their parents, grandparents or other relatives.

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BEANS AND GENES/GENETIC PROBABILITY

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OBJECTIVES:

1. DISTINGUISH **EXPECTED** AND **OBSERVED** GENETIC RATIOS.
2. DEMONSTRATE THAT IN GENETIC CROSSES, AS THE NUMBER OF OFFSPRING INCREASES, THE DIFFERENCE BETWEEN OBSERVED AND EXPECTED RESULTS DECREASES.
3. DEMONSTRATE THE PRACTICAL APPLICATIONS OF GENETIC PROBABILITIES.

MATERIALS:

EACH TEAM NEEDS 2 BOXES*; 100 RED BEANS; 100 WHITE BEANS;
CALCULATOR (OPTIONAL).
NOTE- RED AND WHITE BEANS SHOULD BE THE SAME SIZE & AND SHAPE.

STRATEGIES:

EACH BOX REPRESENTS A PARENT ORGANISM. EACH BEAN REPRESENTS A GENE. EACH BOX WILL CONTAIN 100 BEANS. IN EACH CROSS, A RED BEAN REPRESENTS A DOMINANT GENE (R=RED) AND A WHITE BEAN REPRE- SENTS A RECESSIVE GENE (r=WHITE). THE CONTENT OF EACH BOX IS DETERMINED BY THE GENETIC MAKEUP OF EACH PARENT. THE CLASS IS SEPARATED INTO LAB TEAMS OF 2 OR 3 STUDENTS EACH. 2 MEMBERS OF THE TEAM WILL **EACH** HAVE A BOX OF 100 BEANS. THE THIRD PERSON RECORDS THE DATA.

THE TEACHER BEGINS THE ACTIVITY BY PLACING THE GENOTYPES OF THE PARENTS (P_1) ON THE BOARD. EACH TEAM NOW COUNTS OUT THE APPROPRIATE NUMBERS AND COLORS OF BEANS PER BOX: RR=100 RED BEANS; Rr=50 RED AND 50 WHITE BEANS; rr=100 WHITE BEANS.

THE TEACHER NOW TIMES THE CLASS FOR ONE MINUTE DURING WHICH EACH STUDENT PAIR PULLS 2 BEANS AT A TIME (ONE FROM EACH BOX) AND ARRANGES THE PAIRS IN ROWS: RR;Rr;rr. AT THE END OF THE MINUTE, COUNT THE NUMBER OF RR,Rr AND rr. USING THIS DATA, CALCULATE THE OBSERVED RATIO** FOR EACH GROUP.

NEXT THE TEACHER RECORDS THE RAW DATA FROM EACH TEAM INTO A CHART ON THE BOARD AND ADDS RESULTS TO GET CLASS TOTALS OF RR, Rr AND rr. CALCULATE CLASS RATIOS.

WORK THE CROSS ON PAPER AND CALCULATE THE EXPECTED RATIOS. COMPARE EXPECTED RATIOS WITH OBSERVED TEAM RATIOS AND OBSERVED CLASS RATIOS. WHICH ARE CLOSER TO THE EXPECTED AND WHY?

VARIATIONS:

EACH TEAM CREATES A CROSS, DETERMINES EXPECTED RATIOS ON PAPER, CREATES PARENT GENOTYPES WITH BEAN BOXES, DOES 4 TRIALS OF ONE MINUTE EACH, CALCULATES OBSERVED RATIOS AND DISCUSSES DIFFERENCES BETWEEN SINGLE AND MULTIPLE TRIAL RESULTS.

JELLY BEANS,OR OTHER OBJECTS MAY BE SUBSTITUTED FOR BEANS. SOLICIT STUDENTS FOR IDEAS!

*OATMEAL BOXES; QUART SHERBERT CONTAINERS; ETC. **CALCULATION OF RATIOS: TOTAL RR=A, Rr=B, rr=C. A+B+C=D D/4=E. A/E=1ST RATIO; B/E=2ND RATIO; C/E=3RD RATIO. EXPRESS RATIOS IN WHOLE NUMBERS.

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Biology/ Chemistry

Saving Humpty Dumpty

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Objective(s):

Students will describe how shoe design, manufacturing, retailing, consumer use, and disposal impact environments and societies. Students will discuss ways to reduce, reuse, or recycle resources in the life-cycle for a shoe product. Students will investigate why consumers purchase certain shoe products. Students will examine the influence of packaging on consumer choice, and determine if consumers consider waste disposal, and recyclability, when making purchasing decisions. Students will investigate the shock absorption and energy return of given surfaces.

Materials:

Each of the materials listed below are understood to be per group.

One gallon container	stop watch	measuring cup
Eight hard boiled eggs	graph paper	Nike rubber granules
Three poster boards	stirring stick/ latex gloves.	Worksheets
Rubber Cement	scissors	Nike upper materials
meter stick	New vocabulary list	Nike foam material
marker	tape	Elmer’s glue

Strategy:

1. Review the concept of cycles. Have students give examples of cycles.

2. Tell students they'll be starting a unit of study that uses an athletic shoe as an example of a product cycle.

3. Discuss why they chose the shoes they are wearing, and ask if they considered waste disposal problems that could be caused by the shoes, or the packaging..

4. Have students remove one of their athletic shoes, and examine its make-up.

5. Make a pile of all the athletic shoes in the middle of the floor, and ask a volunteer to measure the length, width, and height of the shoe pile. Discuss the problem of waste disposal for these shoes, then expand to Chicago's, then North America's etc.

6. Have student's measure one shoe. How far would they all reach, if you place them toe to heel? Expand on this idea.

7. Have students weigh one of their shoes, double it, and calculate a class average. Discuss the municipal waste created if everyone buys 4 pr. of shoes per year? Expand.

8. Introduce the concept of cycles, as it might apply to the pile of shoes.

9. Introduce new vocabulary, noting the difference between recycling, downcycling, reducing, and reusing.

10. Tell the students they are going to make some playground material, from used athletic shoes, and when it is dry, they will investigate its shock absorption, and energy return capability.

11. Discuss Nike's efforts in being environmentally conscious about its product waste. They provide playground-surfacing material from product waste. Ask if this is recycling, downcycling, reusing, or reducing?.

12. Students will follow directions given to them on handouts, to test various playground surfaces, using the scientific method. Data will be graphed later.

-

Performance Assessment:

1. Students should be able to measure the materials being used with 100% accuracy.

2. Students should be able to work in cooperative groups with little supervision.

3. Students should be able to write up the experience using the scientific method, with 90% accuracy.

4. Students should understand the concept of a cycle, with 100% accuracy.

5. Students should understand the difference between recycling, downcycling, reusing, and reducing, with 90% accuracy.

6. Students should have collected necessary data with 90% accuracy.

7. Students should be able to graph the data they collected with 100% accuracy.

8. Students should be able to graph the data they collected with 100% accuracy.

9. Students should be able to choose products that are environmentally friendly, given the information discussed and experienced, with 100% accuracy.

Conclusions:

Conserving resources and sharing responsibility for sustainable communities is a job for both consumers and businesses. This can be accomplished by conserving resources at the tech stage of a products life cycle, or by consumers making wise, and environmentally friendly choices, when they buy manufactured products.

Products undergo scientific testing to determine how to reuse and recycle them, or reduce waste made by them. Materials may retain or change their properties in the recycling process. Using controlled variables in experiments to test products helps establish clearer relationships between cause and effect.

Materials have different properties and vary in their abilities to absorb forces or return energy.

References:

Sports Science for Young People, by George Barr (New York: Dover Publications, 1990, 1992).

For a free Nike Air to Earth teacher's guide, kit, and Nike reuse a shoe material, write:

Nike, Inc.; C/o Reuse –A-Shoe/Air to Earth; One Bowerman Drive; Beaverton, Or 97005-6453

Mail between November 1st, and May 31st, or June 1st and October 31st. First come first serve.

More Science Experiments for You: 112 Illustrated Experiments, by Bob Brown (Summit, PA: TAB Books, 1998)

-

The National Recreation and Park Association

http://www.nrpa.org/.

The Playground Safety Initiative

http://www.intramurals.ca/

Acknowledgements:

American Forest Foundation, Washington DC

California Integrated Waste Management Board, Sacramento, CA

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Life in a Drop of Water

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Objective(s):

Grade Level: Middle/ Upper Level -Elementary School

Periods: 4-40 minutes

To observe the wealth of living organisms in a drop of water from our freshwater ecosystems

To classify the types of organisms observed as single-celled or multi-cellular

Use a key or chart to identify and name the organisms found

Background:

Ecologists divide freshwater ecosystems into bodies of running water and bodies of standing water. In the latter the current slows and most suspended particles settle to the bottom. Lakes and ponds are bodies of standing water that will serve as the sources for water samples to investigate freshwater ecosystems.

Protists, which comprise many of the organisms found in the water samples, are mostly single-celled microscopic organisms. They have a nucleus and other cell parts. There are three groups of protists: protozoans (animal-like protists), algae (plant-like protists), and fungi.

Materials:

Pond water, lake water, microscopes, slides, cover slips, droppers, paper towels, small dishes, key of freshwater microorganisms (obtained from a book such as one of the references listed below)

Strategy:

1. Teacher will collect enough pond/lake water in order for each student to have his/her own sample.
2. Review usage and handling of a microscope during period 1.
3. Explain the steps for preparing a slide (period 1). Each student will be required to prepare a slide using the water sample(s). Place a drop of water on the slide and cover with coverslip, make sure no air bubbles are present.
4. Observe the slide under the low power objective lens and search for protists. Watch also for movement.
5. When you find some protists that are not moving or moving slowly switch to the high power objective lens.
6. Draw your protists within circles (about 8 cm in diameter) drawn on sheets of paper.
7. Note the eyepiece and objective lens magnifications and calculate total magnification. This is the eyepiece magnification times the magnification of the objective lens (both should be marked right on the lenses).

NOTE: Pond water can be simulated by preparing a culture of hay infusion. Method: Fill a large jar about two-thirds full of tap water. Let it stand uncovered for three or four days so that air can dissolve in it. Cut some hay or dried grass into short pieces and drop two handfuls into the water. Cover the jar and allow the culture to incubate about two weeks. When the culture is ready, examine several drops taken from different parts of the jar.

Performance Assessment:

Draw and label living organism observed under the microscope.

Use the key to identify and group organism(s) found in the water samples.

Conclusions:

With all life, irrespective of scale, there is a continual struggle and competition for survival. A pond is a miniature cosmos. A diverse range of living forms, both animal and plant, compete for energy supplies, food, space, and other resources.

References:

Daniels, Lucy, Hummer, Paul J. Jr., Kaskel, Albert. 1988. Biology Laboratory Experiences, Merrill Publishing Company.

Alexander, Peter, Fiegel, Marilyn, Harris, Anne F., May, Kenneth W. 1990. Life Science, Silver Burdett and Ginn, Morristown, N.J.

Popular Science Encyclopedia, Volume 6. 1994.

Willie Hoskins - Williams School

Topics in Environmental Science

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Objective(s):

To model the atmosphere of the earth. To build a model to simulate the greenhouse effect. To use diagrams and models to generate data. To analyze and interpret data, especially the results of introducing pollutants into nature. To form scientific hypotheses of how long-term exposure to pollutants will affect the future of the earth.

Materials Needed:

candles, matches, saucers, dirt, rocks, gravel, small plants, water, lamp, thermometer

Strategy:

The instructor strikes the match and lights the candle. Each student is asked what he or she observed. The instructor will hold the bottom of a saucer over the flame. Then blow out the match and examine the underside of the saucer. The same procedure will be repeated with burning paper. Discuss what was observed and conclude that when the yellow part of the flame came in contact with the cool dish, a black substance as well as moisture was deposited moisture also was present. Explain to the students that anything can be called a fuel, and that most fuel contains carbon, hydrogen, or both. When a carbon containing fuel burns incompletely, it usually glows with a yellow color and deposits black carbon as was seen on the saucer. When the flame cools more slowly, the carbon in the fuel joins with oxygen from the air and forms carbon dioxide (CO_2), a colorless gas. The moisture formed on the saucers, because every flame gives off water vapor. This is because the fuel contains hydrogen which reacts with oxygen in the air to form water vapor.

Draw and illustrate all levels of the Earth's atmosphere. Take two clear plastic containers and fill with two centimeters of gravel and one layer of rocks. Add one and a half inches of soil. Plant plants in the dirt, put a little water on each new planting, add one more inch of soil, and water until soil is soaked. Place a thermometer in the soil and be sure the bulb is submerged in the soil and the end is resting on the wall of the container with the number clearly visible through wall or top of container. Cover one of the containers with plastic or plastic wrap. Check the thermometer in both containers after 40 minutes. Discuss and record data and conclude that the temperature increased in the covered container.

Performance Assessment:

Students should observe the changes in the atmosphere and the soil temperature inside the container at different times compared with the atmosphere and temperature of the room.
They should also compare the model greenhouse and the illustration of Nature's Greenhouse. What happens at different temperatures? What happens during photosynthesis?

Conclusions:

Incomplete combustion of fuels can lead to the production of soot. Heat trapped by the cover of an artificial environment increases the temperature of that environment just as thought it happens in the greenhouse effect on Earth.

References:

Navarra, J. G. and Zafforoni, J., **Today's Basic Science**, Harper and Row, New York (1971), pp. 38-47.

Understanding the Greenhouse Effect, Ward's Natural Science, P.O. Box 92912, Rochester, NY 14692 (1989).

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Biology/Chemistry

How Pollution Disrupts Our Natural Environment

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Objective(s):

1. The pupils will be able to design and conduct simple scientific investigations and /or experiments in which observations are made, data are gathered and organized, and reasonable conclusions are drawn.
2. Conduct simple experiments and observations and explain what was discovered.
3. Demonstrate how repeated observations improve confidence in results.
4. Describe conditions that influence change during an investigation.
5. Describe ways that technology is helping to solve the problems of pollution.
6. List 3 causes of air pollution and how it affects plant and animal life.
7. Describe how Global Warming has effected our atmosphere.

Materials Needed:

Experiment No. 1: Each student will participate in the following experiment. (*Note: this can also be a group activity)*. The materials needed in this experiment are: 1 pair of plastic gloves, a thermometer, and 3 plastic grocery bags

Experiment No. 2: The following materials are for a group of 3 to 4 students.

2 clear plastic cups, 1 clear glass bowl, 2 thermometers, water, paper and pencil.

Strategy:

Introduction: Three major problems involved in atmospheric depletion are: 1) ozone-destroying gases, 2) acid rain, and 3) deforestation. All of these problems together cause global warming. The problem with global warming will be discussed and analyzed.

General Information:

Our atmosphere is under increasing pressure from greenhouse gases which threaten to change the climate and put holes in the ozone layer. When the atmosphere is healthy it is an efficient system able to adapt to changes. Without this ability life on Earth would be non-existent. The greenhouse gases have massively traumatized the earth's atmosphere. Chloro-fluorocarbons (**CFC)** from our refrigerators and fire extinguishers destroy and damage the ozone layer. The earth is acidified by sulfur and nitrogen oxides from our cars and factories. The life expectancy of our earth as we know it, today, can no longer sustain good quality air as we know it today for our future generations.

Experiment No. 1:

Note: Gloved hand represents the EARTH

The gloved hand wrapped in plastic bags represents the toxins emitted in the atmosphere.

- Students will take the temperature of the room and record its temperature **(this represents the gloved hand).**
- Distribute 3 plastic bags, 1 pair of rubber gloves and 1 thermometer to each student.
- Students are then to put on the rubber gloves
- Students will wrap one hand with the 3 plastic bags, leaving the other hand in the rubber glove.
- Students will slide the thermometer between the glove and the plastic bags and record the temperature in their journals
- Please note : the temperature of the gloved hand will not be recorded

The students will compare their data with one another and discuss their findings.

Experiment No. 2

The students in this experiment will show how the greenhouse effect gives off toxic gasses that are enclosed in our environment heating up the earth's atmosphere. **Note: This activity should be cone on a sunny day, if this is not possible use a lamp.**

- Fill each cup ¾ full of water
- Before you place the bowl over the glass of water record the temperature in the journals
- Put a glass bowl upside down over one of the cups
- (Note: both cups need to be in the sun)
- Leave the cups in the sun for about an hour before temperature is taken
- Observe the glass bowl and note the changes if any. Record data in journal
- Remove the bowl, take the temperature of the container of water, and record
- Take the temperature of the container of water that was not covered, and record
- Compare temperatures to find the difference
- Through discovery student should be able to note the differences in temperatures.

Performance Assessment:

The students will be assessed by the instructor in the following ways:

- Through their journal writing
- By their ability to execute the experiments
- Through discussions, and
- Through their written explanations on the causes and affects of Global Warming.

References:

Knabel, R., Berey, D., and Matthias, G.. ***Observation and Interpretation of Earth Science. Cebco*** Standard Publishing Company, 1972.

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Recycling

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Objectives:

This lesson was designed for fourth grade students. The main objectives of this mini-teach are to identify and be aware of how much garbage we can produce, identify landfills and their purposes, and explain how recycling saves energy and resources while reducing pollution.

Materials Needed:

Rubberbands, brown paper bag, tape, crayons, scissors, 1 gallon glass jar, measuring cup (250ml), red food coloring, 1 gallon jug water, paper plate, china plate, paper towel, terry cloth dish towel, plastic bag, plastic foam cup, glass, plastic wrap, reusable refrigerator container, carrots in a plastic bag, carrots out of plastic bag. This lesson is designed for whole class participation.

Strategy:

Do an activity called Test Your Recycling Sense. Tell students that you are going to hold up two objects and that they must tell you which object is better for our environment. Paper plate-china plate, paper towel-terry cloth dish towel, plastic bag-paper bag, plastic foam cup-glass, carrots in plastic bag-carrots out of plastic bags. (Note: The second items in each pair, above are better for our environment.)

A second activity is an experiment showing how pollution effects wildlife. Pour one-half cup of water into the gallon jar. Add and stir in two drops of food coloring. Add one cup of water at a time to the jar until the red color disappears. It takes about 7 or more measuring cups of clear water to make the red color disappear. The children should know that when pollutants are put into streams, they go through the entire stream. They do not disappear. They merely spread out just like the food coloring did in the experiment. However, they are still present in the stream and are very dangerous to wildlife and humans.

A third activity is an experiment with rubberbands to determine one effect of plastic garbage pollution on sea animals. Hook one end of the rubberband around your little finger. Stretch the rubberband across the back of your hand and hook the free end on your thumb. Try to remove the rubberband without touching anything. Seals and fish do not have hands. How can they remove the plastic rings from six-packs of beverages if they get these around their bodies.

A fourth activity is to have students sing a recycle song. The name of the song is Recycle Now, sung to the tune of "Three Blind Mice", Verse One, Recycle Now, Recycle Now, For earth's own sake, For earth's own sake, We cannot bury our trash today, Our landfill can't handle it anyway, To recycle is smart for everyone, To save our earth, So recycle now. Verse Two, Recycle Now Recycle Now, For earth's own sake, For earth's own sake, We know how to save a tree every day, To keep our papers in every way, I'll tell my parents to save them too, So we'll save a tree. Verse Three, Recycle Now, Recycle Now, For earth's own sake, For earth's own sake, We know that aluminum and glass are good, To throw away plastic-we never should, I'll tell my parents to save them too, So we'll save our earth.

A fifth activity is to have students to construct a folder using recycled brown bags. Reuse grocery bags to make student folders. Not only is this a great activity for recycling but also this activity can be used as a great listening to directions experience. The cover can be developed as an art project.

1. Unglue and unfold the bottom of a large brown bag, preferably one that is a single thickness of paper

2. Flatten bag by placing the advertising toward you. Pull the front edge with your left hand, and the back folded edge with your right hand.

3. Cut off the bottom at the last fold.

4. Tape the top edges of the bag together. Tape the bottom edges of bag together.

5. Measure 30 cm. down from the top edge, then fold the bottom edge up.

6. Tape edges only. You may want to use staples or glue instead.

7. Fold in half and decorate.

Performance Assessment:

Students will construct a useful folder to hold their school papers. They will construct this folder from recycled brown bags. Upon completion of their folders they will have a clear understanding of how important it is to recycle.

Conclusion:

At the conclusion of this mini-teach the students will be able to identify the ways we can dispose of garbage and the many ways they can recycle.

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Building A Biome

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Objective:

The main objective in this Mini-teach is to show students how different plants grow in each biome.

Materials Needed:

2-L cardboard carton
sandy soil or potting soil
seeds: 5 lima beans, 30 rye grass, 10 impatiens
clear plastic wrap
scissors
lamp (light source)
index cards
tape

Strategy:

1. The teacher will assign each group one of the following biomes: desert, grassland, rain forest, or deciduous forest.
2. Cut the entire front wall from a carton. Poke a few small holes in the uncut side for drainage. Staple the spout closed.
3. Fill the carton with soil to within 3 cm of the top. NOTE: If you have been assigned the desert biome, use sandy soil.
4. At one end of the carton, plant 10 impatiens seeds. In the middle of the carton, plant 5 lima beans. Scatter 30 rye seeds on the soil surface at the other end of the carton.
5. On your index card, write the names of your group, the seeds, and the type of biome. Tape the card to the carton.
6. Water the seeds well. Cover the open part of the carton with plastic wrap.
7. Put the carton in a warm place where it will remain undisturbed. Observe the carton every day.
8. After the seeds have sprouted, and depending upon which biome your group has, give it the following amounts of light and water.

Desert:	little water, 5-6 hours of light
Grassland:	medium water, 5-6 hours of light
Deciduous forest:	medium water, 1-2 hours of light
Rain forest:	much water, no direct light

"much water":	keep soil surface wet
"medium water":	let surface dry, then add water
"little water":	let soil dry to a depth of 2.5 cm, then water
9. Observe the development of the plants in your biome and in the biomes of the other groups. Record your observations.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. In which biome did most of the seeds grow best?
2. Where did grass seeds grow best? The beans? The impatiens?
3. Which plants grew well in more than one biome?
4. How do beans react to little light?
5. Explain why plants grew differently in each biome?
6. Why did the seeds need water when they were planted?
7. What was the variable in the experiment?
8. Predict how the impatiens, lima beans, and rye seeds would grow in the tundra and coniferous forest biomes.

Conclusion:

Students will understand how different plants grow in each biome.

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Zebra Mussels and Water Pollution

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Objectives:

The main objectives of this Mini-teach are to show the proliferation of zebra mussels and their effects on local bodies of water.

Materials needed:

zebra mussels (obtain at any boat dock)
paper plates
5 foot piece of plastic rain gutter
tape
black pepper or poppy seeds
hand lens
rulers
a plastic toy boat
water

Strategy:

1. Begin by going to a boat dock or marina to obtain the mussels. You might also walk along the lakeshore and look for rocks that have some zebra mussels attached to them.
2. If possible allow the students to pull a mussel off a rock.
3. Place the zebra mussels on a paper plate. Allow the students to examine them with a hand lens. Have the students measure their mussels.
4. Have the students identify the basic structures of a zebra mussel.
5. Discuss how the zebra mussel is a biological invader.
6. Have the students brainstorm on possible ways zebra mussels were introduced into Lake Michigan.
7. Obtain a plastic toy boat. Drill two holes in the bottom of the boat. From the top place tape over the holes.
8. Pour water into the boat to simulate how a boat takes on ballast water.
9. Remove the tape to show how a boat releases its ballast water.
10. Retape the holes. Place poppy seeds in the boat to represent a zebra mussel population.
11. Repeat step #8.
12. Place the boat over the rain gutter and repeat step #9.
13. Have the students discuss the proliferation of the zebra mussel.

Performance Assessment:

At the conclusion of the Mini-teach students will be able to answer the following questions:

1. What is the environment of the zebra mussel?
2. How did the zebra mussel reach Lake Michigan waters?
3. Where were zebra mussels first discovered?
4. How are filtration plants dealing with zebra mussel populations?
5. How are boaters and marinas dealing with zebra mussel populations
6. How does the introduction of a new population affect the present ecosystem?
7. How does the zebra mussel population affect water conditions?

Conclusion:

Students will understand how a biological invader was introduced into Lake Michigan and how it affected man and the ecosystem.

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Soil Examination

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Objectives:

The main objectives of this Mini-teach are:

1. Students will recognize different populations in a soil sample.
2. Students will demonstrate and observe water and wind erosion.
3. Students will construct a levee flood control technique.

Materials Needed:

1. Soil Sample - 4 to 6 cubic centimeters of turf per group, hand lenses, paper plates, microscope (optional).
2. Water and Wind Erosion - one piece of 10x13 inch shelving board per group, 2 pieces of 1x2 furring strips, nails or screws, catch container, loose soil, straws, plastic cups, water.
3. Levee Construction - use apparatus constructed in #2, sand, plastic sandwich bags, twist ties, plastic spoons, 2 quart pitcher.

Strategy:

Soil Sample

1. Place the turf sample on a paper plate. Analyze the soil using your hand lens. Look for as many different populations as you can find.
2. Draw any organisms you can identify.

Water and Wind Erosion

1. Attach the furring strips to the shelving board (the 2 inch side should be vertical). Place one strip along the top left side of the board and the other strip 5 inches away (parallel).
2. Make sure the board is placed on a 45 degree incline.
3. Place a mound of loose soil midway up the board, on the opposite side place a piece of turf.
4. Distribute a straw to each group, allow students to blow on both soil samples. Observe what happens.
5. Distribute 2 eight ounce cups of water to each group, allow students to pour the water over each soil sample. Remember to use your catch containers! Observe what happens.

Construction of Levee

1. Use the apparatus constructed in strategy #2, but remove the soil samples.
2. Give each group 6 plastic sandwich bags and 6 twist ties, plastic spoons, and a container of sand.
3. Allow students to fill their sand bags and give them time to develop their own methods for constructing a levee.

4. When students feel their levee will hold back the water, they should raise their hand and the teacher will pour water from a pitcher to test levee strength.
5. If students levee does not hold back the water, allow them to rearrange their sand bags.

Performance Assessment:

At the completion of this Mini-teach students will be able to answer the following questions:

1. What is a population? List the types of populations found in your soil.
2. What is a community? Give an example of a community.
3. From your observations, what held the soil together?
4. What is water erosion?
5. What is wind erosion?
6. From your observations which soil sample had a greater amount of wind erosion? Explain your answer.
7. From your observations which soil sample had a greater amount of water erosion? Explain your answer.
8. When would levee construction be needed within a given area?
9. If your levee successfully held water, explain why? If not, why?
10. What properties of sand make it useful in levee construction?

Conclusion:

At the conclusion of this Mini-teach students will understand the following:

1. Soil contains many different populations.
2. Less erosion occurs in areas where turf exists.
3. When levee construction is needed and how levees are built.

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Food Webs

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Objective:

The main objective of this Mini-teach is to show students that a food web consists of many food chains put together. Also, a food web shows the food relationship in a community.

Materials Needed:

index cards
tape
markers/colored pencils
chalkboard/large sheet of paper

Strategy:

1. Obtain an index card from the teacher. Write the name of one living thing (plant or animal) on the card. Draw a picture of the organism.
2. The teacher will begin by sticking the "SUN" to the board.
3. If you (the students) have something on your card that needs the sun directly to grow, raise your hand then attach your card to the board.
4. Draw the arrows in the proper places, following the energy flow.
5. See if your organism will eat any of the new organisms just posted. If it does, raise your hand. Attach your card to the board. Draw the arrows.
6. Continue to see if your organism will eat any of the new organisms posted. If so, raise your hand and then attach your card to the board. Draw the arrows.
7. Continue to add all the cards, if possible. Try not to get caught without a place in the food web for your organism.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. Where do all living things get energy from?
2. What is a producer?
3. What do the arrows mean?
4. What is a first order consumer? Give an example of a first order consumer.
5. What is a second order consumer? Give an example of a second order consumer.
6. What is a top order consumer? Give an example of a top order consumer.
7. If an organism does not get posted what will happen to it?
9. What is a food web?
10. What does a food web tell us about life?

Conclusion:

Students will understand what a community is and the food relationship that exists within.

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The Effect of Automobile Exhaust on Hydra in an Environmental Chamber

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Objectives:

1) To study the structure and habitat of the hydra.
2) To determine if morphological and/or behavioral changes occur within the animal upon exposure to automobile exhaust.
3) To determine if the hydra may be used as an indicator to detect pollution from automobile exhaust.

Materials:

100 brown hydra (a fresh water Hydrozoan), fresh pond water, 2 environmental chambers, mixed crustaceans including daphnia and artemia (for feeding), auto exhaust, large tire inner tube with delivery tube to the environmental chamber, 10 petri dishes, 6 eye droppers or clean micropipettes, hand lens, one binocular stereo microscope with zoom lens, clock, one microprojector and prepared slides (plain hydra, hydra with spermaries, with ovary, budding and feeding).

Strategy:

1) Fill four petri dishes to one centimeter in depth with pond water. Label the petri dishes A_1, A_2, B_1 and B_2. Place five hydra in each dish.
2) Examine the hydra in each group, describing their morphology and behavior.
3) Place two petri dishes in each of the two environmental chambers.
4) **CHAMBER A** is the experimental chamber connected to the source of pollution. (The automobile exhaust contained within the inner tube).
   CHAMBER B is the control containing room atmosphere.
5) Source of auto exhaust: use a small gasoline engine or automobile to produce gases. Route gases to the inner tube using appropriate attachments and tubing with a two way valve near the inner tube fill valve. Back pressure from the filled inner tube will propel gases regulated by the two way valve routed to the experimental chamber.
6) Fill chamber A with automobile exhaust by using appropriate valves and tubing from pollution source (the large inner tube). Feed gases into the intake valve (located on the bottom of chamber A). Close the exhaust and intake valves on chamber A after gases have filled it to its entire volume.
7) Allow the exhaust and intake valve on chamber B (the control chamber) to remain open to allow the room atmosphere to mix freely within the chamber.

Observations:

1) After each of four 24 hour periods, examine both groups of hydra using the binocular microscope.
2) Compare any morphological changes that may have occurred in the hydra in group A, (chamber A) with the hydra from group B (the control chamber B).
3) Indicate changes by diagrams or descriptions using a data chart.

DAY	# OF LIVING HYDRA	MORPHOLOGICAL CHANGES	BEHAVIORAL CHANGES	OTHER CHANGES

1				
2				
3				
4				

Care of the Hydra

1) Feed the hydra artemia (washed to remove salt) during the observation periods.
   Observe any changes in feeding habits and record them on the data chart.
   Fresh water crustaceans need not be washed, but the food must be free of dead organisms.
2) Replace the water in the petri dishes with fresh pond water daily.
3) Place the petri dishes containing hydra back into their correct environmental chamber.
4) Refill chamber A with automobile exhaust.

Repeat the above experimental strategy

Reduce the trial periods to 12 hours over a four day period. This will result in eight readings, one for each 12 hour period. Modify the existing chart to accommodate the additional readings.

Record and Summarize Your Observations

References:

1) **Modern Biology and Modern Biology Laboratories**
   Albert Towle
   Holt, Rinehart and Winston 1989
   Pages 444-449
2) **Developmental Biology**
   Scott F. Gilbert
   Sinaur Associates, Inc. 1988
   Pages 592-595
3) Journal of Experimental Zoology
   Vol. 132, No. 3, August 1956
   "Growth and Sexual Differentation of Hydra in Mass Culture"
   W. F. Loomis and H. M. Lenhoff
4) **Carolina Protozoa and Invertebrates Manual**
   Carolina Biological Supply Company 1980
   Order # 45-3904
5) Carolina Biological Supply Co.
   Burlington, N.C. 27215
   Hydra Bioreview Sheet # 4214 1979
   Hydrozoa Anatomy Sheet # 4212 1964
6) **Experiments Using the Jewel Environmental Studies Chamber**
   David F. Pray
   Jewel Industries, Inc.
   Hubbard
   1946 Raymond Dr.
   Northbrook, Ill. 60062

FILMS

Audio Materials

Bureau of Visual Education
Chicago Board of Education 1989-1992

1) Stinging Cell Animals: Coelenterates
(S) 02568-82

2) Worlds of Dr. Vishniak
(U-S) 02703

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The Effects of Trash and Garbage On the Environment

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Objectives:

To recognize the importance of solid waste management.
To be able to identify the four "R's"; reuse, reduce, recycle and recover.
To understand what a landfill is.
To analyze individual solid waste management habits.
To understand what is biodegradable and what is non-biodegradable.
To understand why composting is a landfill alternative.
To understand some of the associated pollution problems.
To understand how incineration reduces waste and produces emission.
To view the video tape "The Rotten Truth" provided by the Illinois Department of Energy and Natural Resource in order to enhance individual knowledge of solid waste disposal and the recycling process.
To view the video tape "The Resource Revolution" to learn more about the recycling of plastics.
To learn songs: "You're Really Making Me Sick" and "Reduce, Reuse, Recycle"

Materials needed:

Two 2 liter plastic pop bottles, netting or mesh fabric, rubber band, classroom storage containers (will be decorated by students), plastic bags, soil (dirt), vegetable or fruit scraps, grass, newspaper, plastic and other garbage which will decompose in a landfill, video tape, "The Rotten Truth", provided by the Illinois Department of Energy and Natural Resource, video tape worksheets, video tape, "The Resource Revolution", guessing game activity sheets, aluminum cans, glass bottles, paper napkins, fruit peel and other "Clean" trash items as needed (avoid materials of organic origin), cassette player or tape recorder, television and VCR.

Procedure:

Learn the vocabulary and the categories of waste that occur daily.
Questions--What is garbage? Where does it go?
Discuss landfills and problems that relate to the landfills.
Introduce the concepts of Reduce, Reuse, Recycle and Recover.
Set up a bulletin board divided into sections with the four "R's" categories as headings. Have students begin tacking up items appropriate to each heading and have them explain why the items belong in that category. Some items may be appropriate to more than one category
Review video tape, "The Rotten Truth" and give a short quiz on information from the video.
Make your own Compost Column. Observe and chart what happens over two to four weeks. Discuss the conditions of the various kinds of waste. Discuss biodegradability. Compare the compost to real landfills. From your observations, discuss the potential environmental problems associated with waste in landfills (leachate, contamination of water, smell, methane gas, garbage truck traffic, litter, scavenging birds, loss of natural resources and energy.)

Students will play a game of twenty questions. Without letting the class see what you are doing, put one of the trash objects in a brown paper bag. Show the contents to one student then set the bag aside. The class will then begin asking questions to determine what is in the bag. Some suggested questions are: Do I come from the earth? Am I made from a renewable resource? A nonrenewable resource? Am I made by a person? Am I biodegradable? Am I packaging? Am I a container? Do I contain food? Am I recyclable? Am I compostable?

Separate, prepare and label different types of recyclable trash.

Learn songs: "You're Really Making Me Sick" and "Reduce, Reuse, Recycle".

Evaluation:

Students should be able to tell the difference between natural and human made materials, packaging and non-packaging items, animals, plants and minerals, renewable and nonrenewable resources and be able to identify compostable and recyclable materials.

Conclusion:

As educators and consumers, we are entrusted with the job of teaching children how to make intelligent decisions about solid waste. These decisions can begin in the schools and continue in the homes and stores. The solid waste dilemma will not go away. Changing our way of disposing of trash and garbage will help reduce the amount of garbage that ends up in landfills. Solving the solid waste disposal problem will take a major overhaul in our lifestyle. As consumers and educators, we can accept this challenge and help educate our citizens for change.

References:

Solid Waste Activity Packet (for teachers) distributed by: Illinois Department of Energy and Natural Resource in cooperation with the Cooperative Extension Service of the University of Illinois, Champaign, Illinois. Summer, 1991

Cassette Songs: "You're Really Making Me Sick" and Reduce, Reuse, Recycle" The lyrics are by Dianna Dee Damkoehler and music and singing by Hans Damkoehler. Phone number for requesting an activity packet, video tape and cassette tape is (217)785-0310 - No charge for rental.

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Population Study and Applications Using PTC Paper

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Objectives:

1) To understand the terms dominant, recessive, haploid (monoploid), diploid, genotype, phenotype, scientific sampling and scientific modeling.
2) To know and understand how human population traits such as PTC tasting, widow's peak, bent little finger, tongue rolling and many other traits are distributed.
3) To understand how the various genotypic ratios are distributed throughout a population.
4) To understand the laws of chance and how they are applied to population genetics.

Materials:

PTC Testing Paper (if testing for that trait), graph paper, 2 coins of the same denomination for each team. (Students can provide their own coins.)

Strategy:

To demonstrate scientific sampling, have the class test themselves to see which students in the class are PTC tasters and which are not. Have the students test their families and/or use the data from several classes to provide a sufficiently large representation of the population to work with.
Graph the data. Title the graph PTC Tasters (or PTC Nontasters). Label the horizontal axis "Number of Tasters" (Nontasters) and the vertical axis "Total Number of People Sampled". Plot a "best fit curve". To obtain a ratio, divide the total number of tasters (nontasters) by the total number of people sampled.
To demonstrate scientific modeling, divide the class into partners. Use a "coin toss" with 2 coins of the same type for each pair of partners. Put the coins in the hand, cup the hands and shake them. Open up the hands and allow the coins to roll out onto the table. Put down tally marks in the appropriate columns to

ref**lect the combinations shown.**

Counts	**Possible Combinations**		
	2 Heads	**2 Tails**	**1Head/1Tail**
Total			
Ratio			
Total Number of Flips			

Total the columns. Obtain the ratio by dividing the total of a combination (ex. 2 Heads) by the total number of flips.
In this genetic experiment, "T" is the symbol for tasters and "t" is the symbol for nontasters. "Tt" therefore would be the symbol for a heterozygous taster. Pretend that 2 heads is the "genotype" TT, 2 tails is the "genotype" tt and 1

head/1 tail is the "genotype" Tt. Make a graph of the "tasters" as shown in the data table for your coin flips. Title this graph "Penny Tasters". Mark the horizontal axis "Number of Tasters" and the vertical axis "Number of Flips". Plot a "best fit curve". Compare the curves of the graph that you made of the actual PTC paper tasters with the curve of the graph that you made of the "tasters" that you obtained from your "coin toss".
On a punnett square, show the possible results that would occur for the following matches and record the ratio of tasters to nontasters. A) TTxTT, B) TTxTt, C) TtxTt, D) ttxtt, E) TTxtt and F) Ttxtt.

Study Questions:
1) Based on the data table from your "coin toss", how many people in your "population" would be "tasters"? How many would be "nontasters"?
2) Based on the data table from your "coin toss", determine the ratios of the coin "tasters" to "nontasters". How does this correlate with the data that you have obtained from actual population samples?
3) How does the "coin toss" demonstrate random pairings of genes? (Explain)
4) Gamblers place bets on things that have the greatest odds of occurring. If you were to place a bet on the coin toss, which combination would you bet upon? Why?
5) In looking at the data of the tasters vs nontasters, which genotype comes up most frequently? Which phenotype comes up most frequently?
6) Do you think that scientists are able to come up with reasonable statistics based on scientific sampling and modeling? Defend your answer.
7) Based on your data, can you tell which trait is the dominant trait and which trait is recessive? How?
8) Looking at the data obtained on your graphs, do the curves go up in a predictable pattern?
9) Based on your graphs, if you were to sample 200 people, what do you think the total number of tasters would be? Nontasters? How about if you sampled 500 people? What would be your results if you sampled 1000? How are you able to predict your answers?
10) Based on the data obtained from your punnett square matches, if you were to pretend that the ability to taste was a desirable trait to mate for, which mates would insure the most tasters in the offspring? Which matches would produce the least number of offspring that are tasters?
11) Can two parents that are tasters have children that are nontasters? Explain.
12) The appearance of various genetic deformities and diseases in a population can be studied by the same techniques that we have been using. Do you believe that couples about to get married should have genetic counseling?
13) What if you have found out that you were a carrier for a genetic defect, what action do you think that you should take? What about if it was your spouse?

Extension:
1) Using a pedigree chart test your family for one or several of these traits:

1) PTC Tasting	2) Tongue Rolling
3) Widow's Peak	4) Hair on the 2nd finger joint
5) Attached ear lobe	6) Bent little finger

The more people in your family that you can test, (Grandparents, Aunts, Uncles, Cousins, etc.) the better your data will be. Be sure that you differentiate between blood relatives and relatives through marriage.
2) Set up a data table and include ratios for your results.
3) Set up a graph and interpret your results. Be sure to include a "best fit

curve".
4) Based on your pedigree, try to figure out the genotype for the traits that you have sampled.
5) Based on your graph and ratios, calculate the percentage of the population that carries these features and whether the trait is dominant or recessive. Determine whether you have a large enough population sampled to do these calculations and how the size of the sampled population would affect your ability to have a valid conclusion for your data.

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Biological Communities

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Objectives:

1. List familiar organisms found in several different communities.
2. Distinguish between producer and consumer organisms in your list.
3. Examine and identify as many organisms as possible from a soil community.

Materials Needed:

l. soil sample
2. newspaper
3. vials
4. hand lens
5. four small jars (baby food) with cover
6. isopropyl alcohol or methyl alcohol

Procedure:

You are probably used to thinking of your city, town or neighborhood as a community. But did you know that all animals and plants live in communities too?

Part A.

Based on your knowledge and previous observations, list in table form, at least four organisms found in these communities: Home, Farm, Forest, Ocean and Pond. Identify the organisms as producers or consumers. Circle the organisms that you consider to be consumers.

> Producers are usually green in color and are capable of producing their own food. Consumers are usually brown or other color and cannot manufacture their own food. They obtain food by eating or consuming.

Part B. Soil Community

Collect a variety of soil samples. Place each sample in a plastic bag to prevent drying and then label the bag. Vegetation found on the soil must be included with the sample. Divide students into four groups. Give each group a sample of soil and a sheet of newspaper. Empty the bag of soil on the sheet of newspaper. Probe through the soil and look for hidden organisms. Record in table form the common names of all observed consumer and producer organisms. Record the approximate numbers of each type of organism that is listed. Place small consumer organisms into containers (jars) of isopropyl alcohol for future microscopic study.

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The Effects of Pesticides on the Food Chain

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Objective:

Grade Level 4

Students will be able to generalize that all animals, including people, depend on plants as a food source.
Students will describe and construct a food chain.
Students will tell how pesticides enter the food chain.
Students will discuss possible consequences of pesticides entering the food chain.

Materials needed:

Ecology box showing examples of pollutants harmful to wildlife.
Pictures of plants and animals.
Overhead and transparency "Let's Look at a Food Chain".
5 strips of paper.
Identity cards for game (1-2 hawks, 3-4 shrews, and 9-18 grasshoppers).
50-100 pictures of corn (2/3 yellow, 1/3 another color).
A stapler.
Colored chalk.

Strategy:

Activity 1.

Students will walk around and study the pictures hanging on the walls. Teacher will give some facts about an animal or plant using important vocabulary words, ending each statement with, "Who am I?" The students will find the picture of the organism and identify it.

Example: My rep has me stalking deer, cattle, and man. I have been trapped, shot, and poisoned by both farmers and bounty hunters. Everyone has forgotten that I am grandparent to man's best friend. They even accused me of eating a grandmother. Who am I?

Example: I am a carnivore but I'm not an animal. Who am I?

Activity 2.

Students will write the correct vocabulary word on the board next to it's definition.

Activity 3.

Students will look at and discuss the transparency "Let's Look at a Food Chain." They will identify the seen and unseen organisms and discuss their relationships. They will tell what eats what. They will describe the food chain as the teacher makes a chain with strips of paper.

Activity 4.

Students will put the following organisms in order, making a food chain: shrew, hawk, corn plant, and grasshopper. They will then discuss the relationship of these organisms.

Activity 5.

Students will play a game that will help them understand how pesticides affect a food chain. After the pictures of corn have been scattered around the room or field, the grasshoppers will have 15 seconds to hunt for food. Whatever corn they find, they will put in their "stomach" (a brown paper bag). After 15 seconds the shrew will start to hunt the grasshoppers. After another 15 seconds it is time for the hawks to hunt the shrews. Whoever is tagged by the animal hunting it, must give that animal their "stomach" and sit down. They have been eaten.

Anyone remaining alive will come to the front of the room and empty the contents of their stomachs. The contents will be divided into two groups, yellow and other colors, and counted. Students will record the results on a chart on the board.

Teacher will then inform the students that the colored corn was sprayed with a pesticide. Class will discuss what pesticides are, what they do to plants and animals, and why they are used.

If a grasshopper's "stomach" contained any other colored corn, that grasshopper is considered dead from pesticide poisoning. Any shrews for which half or more of their food supply was other colors would also be considered dead. The hawk may not die at this time, however a large accumulation of pesticide in the hawk's body may result in damage to the reproductive system. The eggs produced may have shells too thin to survive the nesting process.

Conclusions:

This unit should cause students to think about man's responsibilities to wildlife and the possible consequences of their actions. It should cause students to investigate and create ways of living that will enhance the environment for all living creatures.

Evaluation:

Students will construct a food chain of what they ate for dinner.
Students will give two examples of ways in which pesticides could enter the food chain.

References:

Feather, Ralph M.and Ortleb, Edward P. **Science Connections.** Columbus, Ohio:Merrell, 1990.

Koestner, E.J. **Ecology and Energy Action Pack.** Dayton:Mc Donald Corporation, 1977.

Project Wild. Boulder, Colorado:Western Regional Environmental Education Council, 1983.

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The Properties of Air

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Objective:

First Grade

Students will be able to describe the properties of air. They will be able to conclude that air is a gas, that air has weight, that air exerts pressure and that moving air is called wind.

Materials needed:

The following list is for a class of thirty students. Each student should have one:

small plastic zip-lock bag
balloon
bubble gum
straw
9x12 sheet of construction paper

The teacher will need:

two 2 liter bottles
two pans
eight balloons (same size)
tape
styrofoam cooler
hot plate (heat water)
string
hot water
ice
meter stick
clamp
metal pot

Strategy:

These activities and experiments are teacher directed. Each lesson should take approximately fifteen minutes to complete. The exception is the second lesson, which could not be timed.

1. Initially the students should inhale deeply and slowly exhale to ascertain whether or not they see anything. They should inhale again, hold their breath and roll the air around in their mouth to determine whether or not they can taste the air. Finally, the students take three short "sniffs" of air to determine if they smell anything. After each of these activities, the students should conclude that air is a colorless, tasteless and odorless gas.

2. Take two empty plastic bottles and place a balloon over the mouth of each bottle. Put one bottle in a pan of hot water and put the other bottle in a pan with ice. Observe the results. The consensus should be that air exerts

pressure.

3. Suspend a meter stick from a curtain rod. Tie three balloons on each end. Make sure the meter stick is balanced. Remove three balloons (from the same end) inflate them and tie the end of each. Then rehang the inflated balloons. The students should conclude that air has weight.

4. Inflate a balloon. Inflate a plastic bag using a straw. The students should note that air takes up space and that air has no definite shape.

5. Fold a sheet of paper several times to make a fan. Move the fan rapidly back and forth in front of your face. The students should feel the air. They should conclude that moving air is called wind.

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How Organisms Respond To Changes In Their Environment

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Objective:

To observe the reaction of living cells to mechanical and chemical stimuli.

To observe the streaming of protoplasma in living cells.

To identify the relationship between cell response and survival.

Materials:

Living culture
Droppers
Vinegar
Decaffeinated coffee
Sugar
Specimen pipettes
Compound Microscope
Salt crystals
Microscope slides and coverslips
Caffeinated coffee
Cotton fibers

Strategy:

1. Using a specimen pipette, remove a drop from the collected specimen.

2. Place culture on the microscope slide and cover. Focus microscope to locate organism.

3. Having observed the normal activity, some artificial stimuli will be introduced so that the cell response can be observed. Record observed behavior on chart provided.

4. Prepare a new culture specimen if necessary; repeat strategies 1-2.

5. Cautiously place a small salt crystal near some of swimming organisms. Observe and record their response.

6. Continue to add each stimuli along side of covered organism. Observe and record the behavior of the organism.

7. Observe movement. Are new structures visible on the organism? Has movement stopped?

Conclusion:

Bridging the learning experience, is man being affected by environmental pollutants?

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Recycling

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Objectives:

Grade level 9-12

Students will match the vocabulary words with the definitions.

Students will explain the benefit of recycling to the environment.

Students will list three things they can recycle at home.

Students will list several ways that home recycling can be profitable.

Students will discuss how recycling may help solve the landfill problems in urban areas.

Students will name and locate on a map three different landfill areas in the south suburban area.

Materials needed:

The following materials will make one game packet for a class of fifteen.

250-Index cards any size (number depends on class size, each game set requires 50 cards 25 red and 25 blue)

3	18"X 24" Posterboard	1	Overhead projector
1	X-acto knife or razor blade	3	Transparencies
1	Ruler	15	Pencils (regular school pencil)
1	Overhead projector	15	Sheets of graph paper
1	Map of local area (road map)	300	Poker chips red, blue, and white

Strategy:

A. Discussion on landfills and problems that relate to the landfills.

B. Talk about the amount of waste an individual family creates and what it contains e.g. plastic bottles 8.7%, newspaper 41%, aluminum 8.7% and glass 8.2% and misc. 35.6%

C. Show grids on overhead.

1. Grid one shows one square, the square represents the garbage one family creates in one day.

2. Grid two shows five squares, the squares represent the garbage of five families in one day.

3. Grid three shows twenty-five squares representing the garbage twenty-five families create in one day.

4. Talk about the number of families in the area and the amount of garbage created by those families.

D. Intro to home recycling, what materials can be recycled and the benefits to the individual and the environment.

E. Simulation game (for instructions and rules send a self addressed 8 1/2 X 11 envelope to the address above)

F. Graph the results of the simulation.

G. Discussion on the problem of volume in recycling and demonstration of reducing volume and setting up home recycling centers.

H. Homework assignment.

Conclusion:

The purpose of this exercise is to demonstrate to students the effect of recycling on the environment by reducing the amount of garbage going to the landfill. In addition, the economic advantages to the recycler and the community will become evident after playing the game. The lesson will give the student the opportunity to experience some of the problems related to recycling in the home and in the community.

References:

Laurence Sombke, **The Solution to Pollution**, published by Master Media Ltd.

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Urban Effects On Inshore Plankton

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Behavioral Objectives

This lab activity in counting plankton, reinforces the use of the microscope. Differences encountered in count may lead to an exercise in graphing the observed results and stimulate discussion concerning plankton count variation from selected collection sites. The Phenomenological Goal of the lab is the realization of urban water pollution problems. A recognition of cause and effect relationships in an urban area is a concern I feel students should have early in high school biology. Students should arrive at certain conclusions through inquiry rather than being told answers. This microscope lab will have students critically thinking about the discrepancies of plankton counts along our shore and through problem solving techniques they will arrive at a few hypotheses.

Equipment and Materials

Projecting microscope
Slides (gridded,see **Preparation**)
Beral pipet (eye dropper)
Plankton samples (preserved)
Microscope
Coverslips
Plankton collector (see **Preparation**)
Lab notebook or data sheets w/graph

Preparation and Strategies

You could either purchase a plankton net (approx. $45.00) or make one. In order to make one you should use a 3 lb. coffee can with both ends removed. Cover one of the ends with fine mesh netting (50 mesh or smaller) and surround the outside with an embroidery hoop that fits (approx. $0.75). Tighten the hoop while periodically pulling the mesh so there is no sagging. Ideally the mesh must must be taut over the bottom. Tape the embroidery hoop and net along the sides with duct tape to ensure its tight fit. You may have to remove the duct tape and retighten the mesh if it begins to sag. Take the tape with you on the collection trip. The collecting can nets are easy to make and are really inexpensive. Using the plankton net you can now sample any aquatic community. For this lab I used Chicago beaches from 31st Street north to Evanston and then took samples in both Highland Park and Zion, IL. Students can repeat this experiment by resampling beaches along Chicago or areas along Lake Michigan or even their own projects. The possibilities are endless! As a beginning microscope activity the "Urban effects" lab can be used during the first weeks of school focusing on manipulation and viewing skills. This lab could also be used in plankton studies further into the semester. Gridded slides for counting plankton can be made by copying graph paper onto acetate, using Xerox or thermofax process. Cut the desired size and tape the acetate to one side of a slide.

Student Procedure

1. Take specified labeled (site designation) Beral pipet and shake thoroughly.
2. Immediately place 2 drops on your slide.
3. Make a wet mount (glass slide up if using acetate grid on slide).
4. Place slide under the microscope and count the number of plankton.
5. Record the number on your data sheet.
6. Have your partner count the same slide or repeat your count.
7. Record the number on your data sheet.
8. Average the 2 plankton counts and record.
9. Repeat the following procedures with a different sample.

Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J** .
No.of **PLK** Partner 1										
No.of **PLK** Partner 2										
Avg. No.of **PLK**										

(**PLK**-Plankton)

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Acid Rain And How It Affects Our Environment

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Objective

Demonstrate phenomenologically the effects of acid rain on our environment and perform long-term "real-time" experiments.

Materials

6 Petri dishes, pipette, large bell jar or similar item, sulfuric acid, two 2-liter soft drink containers, 4 small pieces of marble or limestone, continuous strip of chart paper approximately 3 ft by 6 ft, pastel crayons or markers, small growing plant, 4 small pieces of raw fish, 2 green leaves, small amount of soil.

Strategies

1. 2 or 3 days in advance, prepare Petri dishes with soil & stone, leaf, and raw fish. One set is to be watered with distilled water, the other wetted thoroughly with 50% sulfuric acid. Keep hidden from view.

2. Prior to the lesson, a) cover an area of chalkboard or wall with the drawing paper; print OUR ENVIRONMENT at the upper right. b) set out the Petri dishes prepared in #1 above, but keep covered from view for the moment. c) make 14 slips of paper, each with one of the following printed on it:

LAKE	FISH	CARS	FACTORY	WIND	SUN	FISHERMAN
PEOPLE	SMOKE	TREES	RAINCLOUD	RIVER	HILLS	HOUSES

3.Pass out the name slips to 14 students at random. Ask the class if they like to draw. (The response should be most positive - I've yet to see a class at any grade level that didn't like "artwork!") Say something like "Let's make a mural about our environment. This should be fun!" Have the slip recipients come up and draw that which is on their slip. Be complimentary and encourage creativity! Guide each artist as to the approximate location of his/her item...(the factory, cars, sun and smoke should be toward the left end of the production and the other items oriented toward the right.)

4. Admire the production! THEN, complete the title by adding "ACID RAIN AND HOW IT AFFECTS", so that the complete title now reads.

"ACID RAIN AND HOW IT AFFECTS OUR ENVIRONMENT"

5. Display the Petrie dishes and show the class how the acid has

affected soil/stone, plant, and animal materials compared to the items in plain water. Discuss briefly, then augment the mural with more smoke, rain, and wind, and describe how acid rain is formed. (Tailor the scientific descriptive language to the grade level involved, i.e., don't get involved with chemical formulas unless the class has had some exposure to them.)

6. Create 3 or 4 groups and have the groups spend about 5 minutes listing what effects they think acid rain would have on the various aspects of their mural. Poll the groups for their ideas and develop a list on a chalkboard. Augment the list with any facets the class may not have considered. Be sure to list all ideas even though not specific to acid rain...indicate that these items "fit better" in different topics and will be covered in future lessons.

7. Set up the following long-term experiment:
   - a - Place the potted plant under the bell jar; Add a Petri dish or other small vessel of 10% sulfuric acid; (Maintain plant normally including acid solution).
   - b - Put about one inch of 10-15% sulfuric acid solution into one of the soft drink containers. Suspend a marble or limestone chip above the solution. Cap tightly.
   - c - Duplicate (a) and (b) with water only as controls.
   - d - Put a piece of raw fish in each of two Petri dishes; immerse one in water and cover, immerse the other in weak acid solution and cover. (Note: these pieces of fish will deteriorate but the effect of the acid solution will become evident over a period of time.)

8. Secure articles dealing with acid rain as available and distribute to the class for their further interest and edification.

NOTE: **SAVE THE MURAL!**

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Filtering Water To Prevent Pollution

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Objectives:
Students will see the techniques that are used to filter our water. Students will gain an idea as to various pollutants which can contaminate our water and an appreciation of the need to keep our water supplies clean. If supplies are available students can filter water at their desks.

Apparatus needed:

1. A large "filtering tube" (This is a large test tube which is open at the top and narrows down into an opening at the bottom. If not obtainable a long necked glass funnel is sufficient.)

2. A large glass fish tank or jar

3. A bag of charcoal pebbles, sand, and gravel obtainable at a retail tropical fish store.

4. Micropore filter paper

5. Petri dishes

6. Chlorine (Obtainable at a retail outlet store that sells swimming pool supplies)

7. A strainer (found in the kitchen) or screening

Recommended Strategies:
For this lesson students should be issued a "lesson outline". This outline, numbered Roman numeral I-VI would enable the students to answer questions as they are presented during the lesson. For example numeral I would require students to define pollution; numeral II would ask students to list three ways in which water is polluted; III would require the students to list four ways in which water is purified; IV would ask students to write what part of the water purification was represented by pouring water through a household strainer; V would ask students to write what occurred when the filtered water from the strainer was allowed to settle in a test tube and what part of the filtration process was represented here; VI might ask students to write what occurred when water was filtered further from the test tube through a filtration funnel lined with layers of charcoal, sand and gravel. Of course the answers to these questions would become clear as the lesson was presented. **Also the outline can be varied to the teacher's tastes.**

The teacher should begin the lesson by asking the student to define pollution. As suitable answers are generated Roman numeral I can be filled in by class. Next teacher could generate from the class what they believe pollutes our water. As answers are generated Roman numeral II can be filled in. This point should be emphasized by "polluting" a fish tank or vessel which has been filled with clean water. Pollutants can be represented by such household products as car motor oil, food dyes, scraps of paper, soil, leaves, clay balls, or coffee grounds. These should be added as students express their ideas as to what pollutes their water. A dramatic effect should be achieved as students see their water "polluted" before their eyes.

Now the teacher should try to elicit an answer to the question: "List four ways by which polluted water is made pure." At this point students could be asked to assemble a "puzzle" which the teacher has passed out to each student. Similar to the Tic-Tac-Toe quiz show on morning T.V. this puzzle, when assembled, spells out the techniques of water filtration; namely screening of polluted water, sedimentation of polluted water, filtration of the water, and chemical treatment of the water. This can be done by drawing a jigsaw puzzle of perhaps 5 pieces on a single piece of unlined paper and simply writing the steps of the puzzle on the drawn pieces. The puzzle can easily be reproduced, cut out, and handed to pupils. The teacher can now elicit a response when the question "What is the first step of water purification" is asked. By reading from their assembled puzzle students can readily answer: "Screening." At this point the teacher can readily filter some of the polluted tank water through a household strainer. Perhaps students can do this at their desks with strainers brought from home. Their outline should be filled out too, i.e., what did straining the polluted water remove from the water? (large particles). Next the teacher can ask for the second step of the purification process. Once again by referring to their puzzle students can readily reply that it is "sedimentation." Now, the water that has been screened can be spilled into a beaker of perhaps 250ml. or a test tube, and allowed to settle. More impurities should settle out. Simultaneously students should further fill out their outline describing what they see.

Again, by reading the puzzle, students can reply that "filtration" is the third step of water purification. At this point the teacher should refer to the filtering funnel which has been layered from top to bottom in the order: one layer of pebbles, one layer of sand, one layer of charcoal. A long stemmed funnel lined with filter paper should be placed below the layered filtering funnel to further filter the water. Of course students are writing what they see on the outline.

Original polluted tank water should be quite a bit cleaner by now. But the demonstration can be further continued handing students a petri dish and three small slices of boiled potato to use as a growth media within the petri dish. Onto one slice a drop of the polluted water from the tank should be placed; onto a second slice a drop of the filtered water from the filtering funnel should be placed; onto the third potato slice a drop of the filtered water and a drop of chlorine mixed with this filtered water should be placed. Cover the dish and allow for bacterial growth for a few days. Students can now complete their class outline sheet by noting on which portion of the potato did bacteria grow. That is, did the filtered water show any difference in bacterial growth than the polluted water? Did the filtered water plus the chlorine show differences in bacterial growth than the other two drops? The completed outline could now be handed to the teacher as the pupil's progress.

It can be noted that a long stem clear glass funnel can be layered with the materials mentioned and used as a "filtering funnel."

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Living Organisms As Indicators of Pollutants In Fresh Water Ecosystems

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Objectives:

1. Use Hydra as a biological indicator of water pollution.
2. Learn about Hydra's natural environment, feeding behavior, reproduction, and reactions to stimuli.

Materials:

2-4 water samples from local ponds, streams, lakes, or rivers
1 glass culture dish (or depression slides)
Hydra population
Hydra medium
Brine shrimp or Daphnea
4-6 droppers or pipettes
microprojector or microscopes
heat filter

Strategies:

A Hydra population can be maintained and reproduced in the classroom. If Brine Shrimp are fed to the Hydra, make sure the salt water is rinsed off, otherwise you will kill your Hydra. Daphnea can also be used as food for your Hydra.

1. With a dropper remove one Hydra (with some water) and place on a culture dish or depression slide. If you use a culture dish, you can prepare more than one Hydra for later observation. Place the culture dish on the stage of the microprojector. Before turning on the light source, place a heat filter above the culture dish (a petri dish with water makes a good heat filter).
2. Observe and record the Hydra's structure and movements. You may also want to discuss Hydra's reproductive behavior and how it changes depending on the environmental conditions.
3. With a dropper place one Daphnea or Brine Shrimp (make sure you have rinsed the salt water off) in the dish with the Hydra. Observe and record your observations on the Hydra's feeding behavior.
4. Look at the pond and lake water samples. Discuss with students which sample they think is the most contaminated and why, and what

effects they think each water sample will have on the Hydra when added to the Hydra's environment. You can use as many water samples as you want, just make sure that only one type of water is added to each Hydra.

5. Add one drop of water from source A to one Hydra sample. Observe and record your observations. Set this sample aside, you will come back to observe it in about 10 minutes.
6. Repeat step 5 using water from source B. Repeat for as many water samples as you want to study.
7. After 10 minutes for each sample, observe again and record if there are any changes.
8. Write your conclusion on your observations.

Evaluation:

1. Research other types of biological indicators and write a strategy for how you could use this organism to determine the presence of contaminants in any kind of ecosystem.

Note: Another demonstration which can be done in class is using Elodea as an indicator. Use the same type of set-up you would use for demonstrating photosynthesis.

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Air Pollution

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Objectives:

1. To develop a greater awareness of the variety and amount of particulate matter in the air.
2. To determine relationships between amount of pollution and time of day or week.
3. To locate general sources of pollution for the area and to develop some suggestions for improving air quality.

Apparatus Needed:

1. Microscope slides
2. Petroleum jelly
3. Masking tape
4. Magnifying glass or microscopes

Recommended Strategy:

Coat one side of each slide with petroleum jelly. Select several different places within your city or residential area to place the slide; e.g., inside school classroom, outside of school classroom, inside your home, outside your home, window ledges, and field. Label the location on masking tape that you attach to each slide. Each student should have three slides to look at, and these slides should have been placed in the places that I mentioned above.

Expose all slides the same length of time (6 hours, 1 day, 1 week, etc.)

After collecting the slides, place them on a sheet of white paper with coated side up. Examine under strong light with magnifying glass or microscope. Each student should have a microscope for this purpose.

Compare exposed slides with control slides that were left indoors in a closed box or drawer.

I asked the students questions about what they observed on the slides. Some of the questions are as follows:

Which of your slides had the most particles?
Where was this slide placed?
Which of your slides had the fewest particles?
Compare results with your classmates find out who had the slide with the highest particle count. Where was it placed?
What is the likely source of this pollution?
How might this pollution be reduced?
What might be done by individuals, community groups, industry, or

government to help to reduced air pollution?

The above questions can also be given on paper and handed out to the students to work on in class.

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Water Purification

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Objectives:

Participants will develop an understanding and appreciation of water purification techniques and their implications for health maintenance. Upon completion of the activities students will:

- explain how polluted water can be a source of disease
- illustrate how a lack of oxygen in water can kill fish
- interpret and explain the water cycle
- express ways of purifying water for drinking purposes
- differentiate ways in which the body uses water

Apparatus and Materials:

Various water samples - tap water, distilled water, well water, mineral water, carbonated water, reverse osmosis water, five day old pond water; glass slide, microscope, candle. (Activity 1.0)
Charcoal placed in large funnel followed with gravel and then sand, flask, paper napkins for filter. (Activity 2.0)
Two jars filled with tap water colored with methylene blue, dried grass placed in one jar. Close jars tightly with screw tops and set for five days, litmus paper. (Activity 3.0)
Decomposition reaction jars with electrode tops, Reverse Osmosis Myron Meter. (Activity 4.0)
Reverse Osmosis Water Purifier and a Carbon Block Filtering Water Purifier. (Activity 5.0)

Recommended Strategy:

This P/A (Phenomenological Approach) lesson is based on the IDEAL Problem Solving Method utilizing the following steps:

I - Identify the problem (What are you asked to do here?)
D - Define the problem (What are the parts? How related?)
E - Explore the possibilities (Interpret and analyze problem)
A - Act upon the possibilities (Plan and follow a strategy)
L - Look for results (Explain results from the strategy)

Vocabulary:

Sediments, desalination, aeration chlorination, toxicity, acid rain, ionized, water borne disease, typhoid, cholera, carcinogens, chloroform, carbon tetrachloride, trihalemethanes, acid rain, suspended solids, dissolved minerals, precipitate, dialysis, respiration, cell oxidation, excretory organs, conductivity apparatus, oncology.

P / A

Nationwide newspaper reports, magazine articles, and network T.V. specials frequently focus on drinking water pollution and its impact on health. EPA scientists point out that over 700 chemicals have been found in America's drinking water and over 34 states have serious drinking water pollution problems. One way of coping with this problematic situation is to identify how water becomes polluted and understand how it can be purified by various methods.

Activity 1.0 Observe drops of water from pond water jar on slide under microscope. Write and illustrate on paper what you have identified and observed.

Activity 2.0 Pour remainder of pond water into filtration set up. Funnel and catch in flask. Record observation, then observe drops of flask water under microscope. **(Activity 2.1)** Add aluminum sulfate to the flask and watch for a sticky jelly like substance - aluminum hydroxide - Observe substance and then observe drop under microscope. Shake and then filter through napkin into another beaker. Examine this water and residue and record what you found.

Activity 3.0 Observe the two jars prepared earlier - Jar A and Jar B - with the same amount of tap water with blue coloration, and dry grass in Jar A. Discuss observation. Use litmus paper to test for pH in both jars. Note results.

Activity 4.0 Illustrate the water cycle and compare it to the process of distillation of water. Define hard and soft water. Explain how boiling of water removes carbonate ions and the deposit collects in tea kettles and steam irons. Have students picture in their minds that frozen distilled water, frozen rain water, winter icicles are generally very clear and un-cloudy whereas frozen tap water is unclear. Have students observe and try to explain. ...NOTE... Pure water is neutral, it has equal numbers of hydronium and hydroxide ions. As water becomes ionized with acids or bases, it moves from the pH #7 position of neutral yellow and the water becomes less pure, this degree of impurity is reflected in the cloudy ice cubes. (Acid rain water, when frozen would look more like frozen tap ice cubes. Can you explain?

Activity 5.0 Place tap water and distilled water in decomposition reaction jars. Insert electrode top and screw tight, plug into electrical outlet. Notice which jar of water is being decomposed and describe your observation. NOTE: These are drinking waters. Which would you prefer to drink. (Observe student faces)

Activity 6.0 Discuss with class the purpose of the oil filtration system in an automobile. Especially the purpose of the filter and oil relative to overall performance of car. Compare and contrast the human excretory system relative to urine and water. Illustrate. Also, explain the role of our skin and nose in the elimination of water. Have students blow breath on cold mirror and note results. Have students do research on the desert animals that never drink any water but make their water from their food. Insert jar over burning candle and note the formation of water. Explain. Students are now ready to focus on the true role of water in the human body. Have them explain two or more ways by which water enters the human body and the purpose of bodily water. Using anatomy/physiology charts, illustrate that over 70% of our daily food is water, over half of our body weight is water, that we lose about two liters of water daily through our sweat, urine, and breathed out moisture - as observed on the cold mirror. Help students to understand that lots of water is good for the body in that it leads to a high volume of urine, causing the kidneys to do less work. Concentrated urine is harder for the kidneys to remove. Explain that this could be one of the reasons why some people have to go on the kidney machines or to take " dialysis treatments." Another reason for lots of the "right kind of water" is that it may prevent urinary calculi (kidney stones). Alert citizens are concerned about their environment and especially keeping our water clean.

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Photosynthesis, Respiration, and the ATP-ADP Cycle

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Objective:

The objective of this activity will be to demonstrate the three processes of photosynthesis, respiration, and the molecular interaction between ADP and ATP and the process by which they lose and gain phosphates in the process of energy conversion. Students will learn about chloroplasts by the construction and labeling of a chloroplast; aerobic respiration in the mitochondria by the construction and labeling of a mitochondrion; and the chemical interaction of ADP and ATP by atomic modeling of ADP and ATP molecules as well as a game.

Materials Needed:

(5) bags each of red beans, black beans, and lima beans.
(30) Ritter Dishes (clay planters/potting dishes)
(30) pieces of construction paper (strips preferably)
(5) bags of potting soil
(5) containers of glue
(5) packages of thin tipped markers
(5) packages of thick tipped markers
(10) packages of sponges (green, brown, and light green)
(10) tennis balls

Strategy:

Photosynthesis consists of the absorption of light by chlorophyll pigments and conversion of this light to chemical energy. This occurs in organelles called chloroplasts on membrane systems known as thylakoids. Respiration reverses the process of photosynthesis, releasing the stored chemical energy. Respiration occurs in organelles called mitochondria. ATP consists of three parts, adenine, ribose, and (3) phosphate groups. Adenine when bonded to ribose gives us adenosine. Adenosine plus three phosphate groups gives us ATP. Adenosine bonded to two phosphate groups is ADP. In the energy production cycle in the chloroplasts and mitochondria, energy is stored when ATP is produced from ADP and a phosphate group "P".

The ATP/ADP cycle provides energy for cellular activity. When energy is necessary the third phosphate group breaks off from ATP. This forms ADP and releases energy. When a phosphate group is freed up, it may move on to another molecule in a process called phosphorylation. The molecule gains both the phosphate group and the energy. ATP synthesis is catalyzed by ATP synthetase. Photosynthesis, respiration and ATP/ADP are related. Photosynthesis stores energy, respiration releases it, and ATP is the central molecule in this process.

The students will use the thin markers to mark the chemical symbols for each of the ADP/ATP chemical components on the surface(s) of the beans. There will be (1) chemical symbol marked on each bean. Red beans may be used to represent the carbons, lima beans to represent the hydrogens, black beans to represent oxygens, and white beans to represent the nitrogens; long grain rice will be used to represent the single and double bonds. After the beans are marked, they will be chemically arranged to represent the structures of the ATP/ADP molecules. The beans will be glued to a sheet of construction paper. After the glue has dried, the construction paper with the beans will be placed in a Ritter dish. The Ritter dishes will be at least half filled with soil and watered. The germination of the beans will occur within a few days. This germination is followed closely by the beginning of the photosynthetic process which we have been studying.

The students will each be issued 1-2 sponges. The students will carve the sponges into chloroplasts. The residual sponge will be used create the thylakoids. Half beans will be used to represent ATP synthetase molecules. A similar activity can be used to create models of mitochondria.

Using tennis balls the students will play a game of catch to demonstrate the loss of 1 phosphate to form ADP from ATP and the gain of one phosphate to form ATP from ADP. The first toss will represent ATP to ADP; the return toss will represent ADP to ATP and so on. The process (the game of catch) will be repeated until the students have clearly demonstrated their knowledge of the phosphate loss, phosphate gain process.

Performance Assessment:

Students should be able to explain the ADP/ATP cycle with 90-95% accuracy after they have completed both components of the exercise. Students should be able to relate the process directly and indirectly to chloroplast and mitochodrial function with 80-90% accuracy. Students should be able to explain the gain of a phosphate and the loss of a phosphate with the same degree of accuracy. This will be supplemented by a Timer-Board Activity. What does the Timer-Board Activity consist of? The students will be asked individual terms and vocabulary related to the activity which we have just completed.

Each participant will be given at least 60 seconds to define a particular term or answer a particular question. Each student will be given (5) points for every correct response up to a maximum of (50 points) for an "A" on the Timer-Board Activity. Total points will be written on a pre-printed scoring sheet beside the names of each of the students (our scoring sheet is our scoring board). The scoring sheet is blocked off so that a number (5) in red ink can be written in every block depending on how the student scores. There is a residual 2 1/2 points for answers that are not wrong but simply inaccurate.

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What's the Matter?

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Objective:

To Understand the Chemical Properties of Matter

Materials Needed:

Vinegar
Steel Wool
Household Ammonia
Tablespoon
Two Small Baby Food Jars
Wooden Matches

Strategy:

Strike Match. Observe what happens to the match as it burns.
Fill one-half of one jar with steel wool.
Add enough vinegar to cover the steel wool.
Write IRON ACETATE on the side of the jar.
Allow the jar to stand undisturbed for five days. (A chemical reaction between the vinegar (acetic acid) and steel wool (iron) that produces iron acetate.
Pour one tablespoon of liquid containing iron acetate into the second jar. Pour one tablespoon of household ammonia (ammonium acetate) and stir. Note and record observations.

Observations:

Chemical reactions do not create or destroy matter, but only rearrange the combinations of atoms in matter. For example, wood in the match stick (which contains carbon, oxygen, and hydrogen), plus oxygen in the air combine in a chemical reaction to form water (which contains oxygen and hydrogen), carbon, and carbon dioxide (which contains carbon and oxygen). Chemical reactions often give off energy (for example, the chemical reaction of the match burning gives off heat and light).

In the case of the green blob, iron plus vinegar produces iron acetate. Iron produces iron acetate. Iron acetate plus "ammonia" (ammonium hydroxide) produces ammonium acetate and iron hydroxide (the green blob)

In biological systems the same principles apply. Living things contain the same atoms as the non-living part of the earth, but the "chemical reactions of life" rearrange the atoms in the non-living organisms into new combinations (the chemicals of life).

Performance Assessments:

As a result of focusing on the chemical properties of matter, and the above activities, students will be able to answer the following questions:

What changes occurred when the match was burned?
What happened when the iron in the steel wool combined with the vinegar?
What happened when ammonium hydroxide and iron acetate combined?
In our experiment, The Green Blob, was a new material produced? Why or Why not?

Conclusion:

Students will understand the chemical properties of matter and its relationship to living and non-living things.

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What's the Matter?

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Objectives:

To Understand The Physical Properties of Matter
Designed for 6th and 7th Grade

Materials:

Apples(2)	Oranges(2)	Feather	Book of Matches
Ice Cubes	Graduated Cylinder	Beaker	Plants
Water	Wood	Flask	Book
sugar	Steel	Paper Cups	Spoons
Salt	Paper	Rocks	Single Beam Balance

Part A: To Recognize that Matter is Anything That Takes Up Space and Has Mass.

Procedure:

Groups of 4 or 5 students.
Pass out sugar, salt, wood, steel, paper, paper cups, rocks, plants, and spoons.
Place 3 or 4 objects on students desk.
Have the students touch, smell, taste, and look at the objects.

Questions:

How can one tell the difference between each object?
What do the objects have in common?
What do we call all material?
Look at the objects again. Are there differences in length, width, and thickness?

Part B: To Show That Gravity Controls the Weight of an Object.

Procedure:

Drop a book on the floor.
Drop a book and a feather on the floor.
Drop a book and a book of matches on the floor.
What is gravity?
What does this activity tell you about what gravity does to objects?
Discuss why an apple and orange of similar size may be different in weight.
Discuss reason why masses of different objects are not the same.
Discuss density.
Place the apple on the scale and weigh it.
Cut the apple in half and one half and two quarters;
Weigh the apple again.

Weigh the orange.
Cut the orange into four equal pieces.
Weigh the orange again.
Observe what happens when you weigh the apple and the orange.
Observe what happens when you weigh the cut apple and orange.
Record your observations.

Questions:

What is mass?
Can the mass of the object change?
Can the weight of an object change?
Did the mass of the apple change? Did the weight change?
Did the mass of the orange change? Did the weight change?

Part C: To Show That all Matter Has Volume.

Procedure:

Cut a wood block and a sponge so that they have the same length, height, and width as each other.
Place the wood and the sponge on top of each other.
Weight both the wood and the sponge.
Observe that they are the same dimensions.
Record your observation.
Fill a flask with water and freeze it.
Measure the volume of the ice in the beaker.
Cover the beaker with plastic wrap and let it thaw at room temperature.
After the water has melted, record the volume of water in the flask.
Place flask containing cold water over beaker.
Record the amount of water in the flask.
Fill graduated cylinder with 300 ml of cold water.
Place paper towel over boiling water.
Record your observations.
Remove paper towel from top of beaker.
Place graduated cylinder containing cold water over beaker.
Record your observations.

Questions:

What is Volume?
What is Density?
What Causes Matter to Change State?
What are Molecules?
What Causes Molecules to Speed Up?
How May Mass and Volume Be Measured?
What Causes Molecules to Slow Down?

Performance Assessments:

As a result of focusing on the Physical Properties of Matter, students will be able to:

Tell What Atoms Are

Tell What Two Things Control the State of Matter
Tell What a Molecule Is
List Three States of Matter
Describe Solids, Liquids, and Gases in Terms of Shape and Volume
Develop the Skills of Observation and Inference
Explain Density

Conclusion:

Students will understand the physical properties of matter and answer the questions.

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The Chemistry of Water

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Objective:

Grade level: Ninth

1. To discuss the phenomenological properties of water.
2. Discuss and demonstrate solubility of liquids.
3. Students will define and give examples of expansion.
4. Demonstrate surface tension individually and as a group.
5. Students will make a water molecule combining the class molecules together forming water.

Materials needed:

(For each student.)

Activity 1

One large beaker, black pepper, one small needle, water, and a dish washing detergent.

Activity 2

One large styrofoam ball, two small styrofoam balls, two toothpicks.

Strategy:

Review properties of water showing the natural existence of water in three states. Discuss and demonstrate the solubility of water using sand, sugar, oil, vinegar and salad dressing. The students will readily recognize that all substances do not dissolve in water and that there are other liquids that are good solvents.

Students will observe a can of coke that has been left in the freezer overnight. What happened? Why? Car radiators sometimes freeze in winter. Why?

In Activity 1, students will fill a large plastic container with water. Sprinkle the surface of the water slightly with black pepper. Discuss observations. Drop a dish washing detergent in the center of the dish. Observe what happens. Class will discuss observations.

Place some water in a large plastic cup. The water can be at any level in the cup. Let the water stand for two or three minutes. Place a small needle on the surface of the water. Observe what happens? Why? Place a small needle on the surface of the water using forceps. Discuss observations. Was it easier to place the needle on the surface of the water with your fingers or with the forceps? Class will discuss their observations and give reasons as to what they think happened.

In Activity 2, students will construct a water molecule showing how the hydrogen atoms are bonded to the oxygen atom using toothpicks. The class will bond their molecule with another molecule (in a straight chain) to show how water is formed. The water molecule looks very much like a Mickey Mouse hat. It has a covalent bonding and is polar because of the 105 degree angle between the hydrogen atoms.

Conclusion:

The natural existence of water in three different forms is indeed a phenomenon. Plants and animals cannot survive without it. We use it in every aspect of our daily lives. Solubility, expansion and surface tension are some of the properties that makes water unique.

We should not waste or pollute water because there are some countries who do not have any water. We should always remember those without and create ways to help.

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Chromosome Karyotyping

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Objectives:

1. Students will be able to demonstrate a microtechnique for reliable chromosomal analysis of leucocytes obtained from peripheral blood.
2. Students will be able to prepare a karyotype from the chromosomes of a normal human male or female.
3. Students will be able to use the karyotyping techniques for diagnosing a chromosomal disorder.

Apparatus and Materials:

1. Centrifuge and Tubes
2. Construction Paper
3. Coplin Jar
4. Deionized and Distilled Water
5. Fixative Solution
6. Flat- ended forceps
7. Human Chromosome Kit (order)
8. Human Chromosome Photographs
9. Human Karyotype Forms
10. Incubator or Hotwater Bath
11. Methanol
12. Microscope Slides and Cover Slips
13. Oil Immersion Microscope and Oil
14. Overhead Projector
15. Ruler
16. Scissors
17. String or Yarn
18. Tape or Glue
19. Tape Player and Music
20. Transparencies
    a. Cell Mitotic Stages
    b. Birth Certificate
    c. Chromosomes: Normal and abnormal
    d. Human Karyotype
21. Xylene

Recommended Strategy:

Order chromosome kit at least three weeks prior to use
Set up microtechnique one week prior to use

I. **Background:**

A. Discuss myths, superstitions and misconceptions associated with biological inheritance and human development.
   1. State an example of a heredity superstition.
   2. Enlist additional examples from the students.

B. State a brief history of Genetics, include Genetic Principles and how teaching has helped in eliminating misconceptions.

II. **Motivation:**

Before class place two large circles on the floor one inside the other using the string or yarn (represents membranes of cell). Use 2 different colors of construction paper to make hats, label one side chromatin and the other side chromosome. Make 2 centromeres cut in half and label.

A. Discuss the normal chromosome complement of human males and females.
B. Explain the history of the establishment of the correct chromosome number in humans.
C. Review cell division - explaining how sex cells receive too much or not enough genetic material.
D. Choose a short and a tall student to dance the "Chromosome Jig."
E. Note the two circles on the floor and discuss purpose, sizes,

arrangement, where "chromatin" should stand, and cell stage represented.

F. Place construction paper hats on dancers heads (chromatin sides showing, each hat is a different color).

G. Dancers will now perform within the nucleus, the remaining students will assist in providing clues:

Note Steps may be shown on overhead during performance or for review after the dance. Soft music may be played.

1. New cell stage - Interphase
    - (a) Chromosomes indistinct (chromatin)...dancers kneeling
    - (b) Chromosomes unravel (chromosome sides of hats showing)
    - (c) Chromosomes duplicate and gradually coil
        - (1) 2 more dancers, same size as originals, come in wearing chromosome hats.
        - (2) Place centromere on locking hands of each two dancers.
2. Prophase
    - (a) Chromosomes contracted enough to become distinct
    - (b) Chromosomes twist around while constantly contracting
3. Metaphase
    - (a) Chromosomes are fully contracted
    - (b) Chromosomes separate
    - (c) Teacher quickly, without students being aware of purpose, sprinkles confetti (chemical) on dancers to stop metaphase, before the spindle fibers appear. Puzzled dancers will stop dancing and separate.
    - (d) Teacher states, "now nuclear membrane disappears," and asks a sitting student to remove it

III. **Development:**

When possible list responses on chalkboard

A. Discuss the purpose and name of the chemical (confetti).

B. Describe the position of the dancers, thank dancers as they sit.

C. What process is seen when chromosomes stop in this case? (Ans. Arrested metaphase)

D. Ask why arrest metaphase for chromosome studies?

E. Ask how does one obtain his/her own chromosomes?

F. Ask why would one need to see his/her chromosome?

G. Show on overhead:

- (1) Birth certificate showing an error in stating sex
    - (a) Ask class to study certificate and note any errors
    - (b) Use this to lead into karyotyping
- (2) Examples of the following karyotypes:
    - (a) Normal male and female - try your own
    - (b) Chromosome set used to make karyotypes

IV. **Activities:**

A. Laboratory Exercise - Human Chromosome Study/Karyotyping

Allow time for students to complete the following:

- (a) Prepare a normal human karyotype
- (b) Prepare an abnormal human karyotype
- (c) Teacher designed analysis and discussion section

B. Chromosome Syndromes

List disorders and determine name and sex affected by the disorder.

V. **Evaluation Prepare an evaluation exercise**

VI. **Extension** (Homework Exercise)

A. List a hypothetical anomaly, its causes, symptoms and probabilities of occurrence, rank the likelihood of aborting the fetus on a scale of 1-5. 1 representing never, and 5 always.

B. Write a paragraph supporting your decision. If you are opposed to abortion in all cases, then write a paragraph that supports your values.

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The Role of Enzymes

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Objectives:

To explore the role of enzymes in chemical reactions.
To determine what kinds of cells contain more catalase than others.

Apparatus and Materials:

Chalk
Potato
Raw hamburger
Raw liver
Boiled liver
Spinach leaf
Carrot
3 percent hydrogen peroxide
Manganese dioxide
Boiling water
Graduated cylinder
scalpel
10-mL test tube
Test tube rack
Spot plates

Recommended Strategy:

Phenomenological approach
Comparisons, analogies, and summarization

1. Review the following terms: organic compounds, dehydration synthesis, hydrolysis, potential energy, kinetic energy, and activation energy.

2. Place two keys on an overhead projector and have the students compare them to the structure of enzymes.

3. Using paper models on the overhead projector, demonstrate to the students the role of enzymes in hydrolysis and dehydration synthesis.

STUDENTS ARE NOW READY TO BEGIN THE EXPERIMENT.

PART I

Measure 2 mL of hydrogen peroxide, H_2O_2, in a graduated cylinder and pour it into a test tube. Add to the test tube enough manganese dioxide, MnO_2, to cover the end of a scalpel.

1. Describe the reaction.
2. When the reaction ends, add 2 mL more hydrogen peroxide to the

test tube. Does the reaction occur again?

3. When the reaction ends, add a little more manganese dioxide. Does the reaction occur again?
4. Based on your observations, which of the following statements is the most probable assumption? Circle the letter of the statement you choose.
   a. The hydrogen peroxide is used up and the manganese dioxide remains unchanged.
   b. The manganese dioxide is used up and the hydrogen peroxide remains unchanged.
   c. Both the hydrogen peroxide and the manganese dioxide are used up.
   d. Neither the hydrogen peroxide nor the manganese dioxide is used up.

PART II

Place three small pieces of each: chalk, hamburger, liver, spinach, potato, and carrot on a spot plate. Pour enough hydrogen peroxide on each food stuff to fill the depression. Be sure to prepare the same amount of each food stuff and to keep them separate.

Note the speeds of the reactions. The faster the reaction, the more vigorously the liquid bubbles and the warmer the container becomes. Make a data chart, list the items in order from the fastest reacting to the slowest reacting.

5. Which substances contain more of the enzyme, those at the top of the list or those at the bottom?
6. Are the meats near the top or bottom of the list? the plants?
7. Which, if any, of the items did not produce a reaction? If a substance produced no reaction, explain why.

PART III

Place three small pieces of raw liver and three small pieces of boiled liver on your spot plate. Fill each depression with hydrogen peroxide.

8. Describe what happens.
9. Based on this test, what assumption can you make about the effect of boiling enzymes?

ANALYSIS

10. What two products does hydrogen peroxide change into when it breaks down?
11. What effect does a catalyst have on this chemical reaction?
12. What do you think causes the bubbling in this reaction?
13. What is the function of an enzyme?
14. What enzyme acts on hydrogen peroxide in living organisms?
15. Would this enzyme act on chemicals other than hydrogen

peroxide? Why or why not?

SUMMARY QUESTIONS

1. Summarize what you have learned about the role of enzymes.
2. What analogy can be best used to describe the role of enzymes?
3. Write a list of terms that were used to help you to understand how enzymes operate. Use each term in an appropriate sentence.

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The Coding of Protein Molecules By D.N.A.

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Objectives:

Use paper models to demonstrate how DNA controls protein synthesis.

Use paper models to show the role of mRNA in protein synthesis.

Use paper models to show the role of tRNA in protein synthesis.

Apparatus needed:

Paper models to represent the following molecules: 5 deoxyribose thymine, 5 deoxyribose adenine, 1 deoxyribose cytosine, 1 deoxyribose guanine, 3 ribose uracil, 2 ribose adenine, 1 ribose cytosine, 2 tRNA molecules, 2 amino acid molecules. Cut out models beforehand and place in an envelope. Print the DNA Neucleotide sequence A,A,T,A,G,T on the envelope. Prepare a large "place mat" on which to assemble your protein molecule. Construct by taping two large sheets of construction paper together. Represent the nucleus by drawing a half circle on the left edge of your "place mat". Make it wide enough to accommodate a double strand of nucleotides. Make several circles to the left of the half circle to represent a few ribosomes in the cytoplasm.

Strategies:

Remove the puzzle pieces from the envelope. On the "place mat", start at the left edge inside the red half circle, arrange your DNA nucleotides in the linear sequence written on the envelope. Attach the corresponding nucleotides to make the right side of the DNA ladder. (Place the results on the board)

Unzip the six nucleotides from the right half of your molecule.

Attach the appropriate ribose nucleotides to the left half of your DNA nucleotides. (Record results on the board)

Slide the ribose nucleotides to the right side of the half circle representing the nucleus and turn RNA nucleotides right side up.

Attach the appropriate amino acid molecule to the appropriate tRNA molecule.

Move the attached amino acid along with the tRNA to the appropriate bases on the RNA template. Try to arrange these molecules so that they will be built on top of a circle used to represent a ribosome.

Students will identify what amino acids they have put together by looking at a chart showing the codons used to represent various amino acids.

CONCLUSIONS: Each student has built a dipeptide made up of the amino acids leucine and serine. Large protein molecules are built the same way, but with many more amino acids being brought to the mRNA template by tRNA.

EVALUATION: Answer the following questions to show understanding of protein synthesis:

1. To join tRNA molecules to the mRNA pattern, which sequence of tRNA molecules will match base pairs of the U,U,A sequence in mRNA?
2. Which tRNA sequence of bases can join U,C,A sequence in mRNA?
3. How does the sequence of bases on mRNA control the type of tRNA joining it?
4. A base sequence of A,A,A mRNA could only join with what sequence of bases in tRNA?
5. What specific amino acid is brought to the mRNA by a tRNA with a terminal sequence of A,G,U? (Use an amino acid - codon table)
6. What amino acid is brought to the mRNA by a tRNA terminal sequence of A,G,U?
7. How many half rungs of mRNA are responsible for the coding of one amino acid?
8. A protein molecule consists of the following amino acid sequence: leucine, glutamine, tyrosine, leucine, serine, serine. What would be the sequence of tRNA molecules responsible for forming this protein?
9. A ribosome receives the following mRNA message: AAA, CGA, GAA, GUU. What will be the sequence of tRNA bases joining the mRNA molecule? B. What will be the sequence of amino acids formed from this code?
l0. Explain how a sequence of bases in DNA can instruct a cell to produce a certain protein.

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Natural and Synthetic Fiber

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Objectives:

To identify wool, cotton, linen, and silk with the aid of a microscope. To identity several natural and synthetic materials placed on a table.

Apparatus needed:

microscope, table, cotton fiber, linen fiber, silk fiber, wool fiber, leather belt, styrofoam cup, polyester bottle, rayon blouse, vinyl clothes bag, wood plank, nylon stockings, polyester and cotton shirt.

Recommended strategy:

The students were given a list of vocabulary terms to define prior to this assignment. Arrange the terms written on the board in two categories. "Natural and Synthetic Fibers." Student will be given a description of the four natural fibers placed under the microscopes as well as the natural and synthetic fibers placed on a table. Identify the types of fibers placed on the slides under the four microscopes as well as the items placed on the table.

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MOLECULAR SHUFFLE

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Objective:

To observe how a selectively permeable membrane works.

Materials:

cellophane dialysis tubing
glass rod
string
starch suspension
80% glucose solution
distilled water
3 beakers
medicine droppers
2 test tubes
Benedict's solution
Bunsen burner
tripod
iodine

Strategy:

Soak a 20-cm section of cellophane dialysis tubing in water for a few minutes. Rub the ends between your thumb and index finger until the ends separate. Insert a glass rod to hold it open. Twist one end and tie it tightly with string. Remove the glass rod and then fill the dialysis bag 3/4 full with starch suspension and 1/4-full with 80% glucose solution. Tie the top of the bag with string. Leave a loose piece of string 10-15 cm long. Rinse the outside of the bag with distilled water. Leave the string outside the beaker so that you may remove the bag from the water. After 20 minutes withdraw a dropper full of water from the beaker. Place this liquid in a test tube and add 10 drops of Benedict's solution. Heat in a boiling water bath for 10-15 minutes.

While the water bath is boiling, place 30 drops of the liquid from the beaker in a test tube. Add three drops of iodine. Observe the color of the water after the iodine has been added. (If it turns blue or black, then starch is indicated.) Now add 20 drops of iodine to the water in the same beaker and observe any color changes. Report your results by answering questions 1-8.

Evaluation:

The students should answer the following questions:

1. What happens when you heat Benedict's solution and some water from the beaker?
2. Explain your results?
3. Do you note any changes in the amount of liquid in the beaker?
4. What conclusion can you draw from this observation?
5. What is the purpose of adding iodine to the liquid from the beaker?
6. What happens when you add iodine to the liquid from the beaker?
7. Describe any changes observed when iodine was added to the beaker?
8. If a change has occurred, what does this indicate?

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CONSTRUCTING A DICHOTOMOUS KEY

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Objectives:

To construct and use dichotomous keys.

Materials:

Shoes (Use one shoe from each of 10 students).

Worksheets: "Using A Dichotomous Key"
"Imaginary Animals"

Strategies:

Procedure:

1.Arrange chairs in a circle.

2.Instructor takes off one shoe and place it on the floor in the middle of the circle.

Dialogue

3."There's one of my shoes, so let's have a shoe from about ten of you".

4.Tell the students that they are to divide the shoes into two piles. Tell them the piles don't have to have equal numbers of shoes but, that they all have to agree on some obvious characteristic that will distinguish the shoes in one pile from the shoes in the other pile.After agreement is reached,tell the students a record of the agreement will be kept on the board.

5.Draw two horizontal lines some distance apart on the chalkboard. Label the lines with the agreed upon characteristics. (Fig.1).

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__________

__________
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FIG.1

6.Return to the pile of shoes. Tell the students one pile will be pushed aside for the moment but, now they must again divide the pile of shoes into two distinct piles. After agreement is reached add this information to the chalkboard sketch. (Fig.2).

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                  _____________
_______________/
               \_____________
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FIG.2

7. Continue the procedure of dividing the shoes into two distinct piles and adding the information to the sketch until there is only one shoe with the identifying characteristic, at which point the shoe is identified and the

owners name is added to the sketch (Fig.3).

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                                                         ______________
                                           _____________/
                             _____________/             \______________
                                          \_____________
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FIG. 3

8. Divide the second pile of shoes in the same manner as the first pile until all the shoes have been identified.
9. Push all the shoes back together in one pile[Adding perhaps a shoe from the distance past or one with characteristics unlike those used in the original construction].
Discuss the meaning of the term dichotomous explaining that the word means "two forks".
10. Tell the students that dichotomous keys usually appear in a more compact form and that the diagram can be easily converted by adding numbers to each characteristic used. Label the diagram in numerical sequence following the same order the characteristics were agreed upon.
11. Have the students redeem their shoe by taking it from the pile and placing it on the correct branches of the key which will lead to its' correct identification. After all the shoes have been redeemed the shoe added earlier should remain. Ask a student to follow the key until the shoe is identified. Students should discover that a key works only for identification of those items used in its' original construction.
12. Pass out the two worksheets. Complete the " Using A Dichotomous Key" sheet in class. Assign the " Imaginary Animals" sheet for homework.

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ACTIVE TRANSPORT ACROSS THE PLASMA MEMBRANE

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Objective:
The student will be able to comprehend that energy is required to move substances across the cell membrane against the concentration gradient.

Materials:
Dry Yeast
0.75% Na_2CO_3
0.02% neutral red dye
0.75% acetic acid
filter paper discs to fit funnels

Strategies:
Demonstrate the dye (neutral red) by adding weak acetic acid. Color change occurs.
Place 25 ml of 0.75% Na_2CO_3 in a large test tube. Add 1 gm dry yeast. Boil solution gently for 2 minutes. Label the tube A.
Place 25 ml of 0.75% Na_2CO_3 in a large test tube, warm, and then add 1 gm dry yeast. Allow the solution to sit for 10 minutes(to activate the yeast) Label the test tube B.
Add 25 ml of 0.02% neutral red to test tube A. Observe and record color change.
Add 25 ml of 0.02% of neutral red to test tube B. Observe and record color change.
Filter a portion of the contents of each test tube. Observe and record color of cells left on the filter paper and color of solution of each test tube.
Think about your observations and answer the following questions:
a) Did the dye enter the cells of either test tube?
b) Did Na_2CO_3 enter the cells of either test tube?
c) Is the cell membrane of the cells of A or B permeable?
Conclusion? Either the cells of test tube B put out something to change the solution or the dye entered the cells and was changed in the cytoplasm. (It is known that the cytoplasm is slightly acidic)

Add an equal amount of acetic acid to the remaining contents of test tube A.
Observe and record any color change.
Filter a portion of the suspension. Record color of cells.
Remove the filter paper of the original filtration of test tube A contents.
Place a drop of acetic acid on the cells.
Observe and record any color change.

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Biology/Chemistry

Food Chain

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Objective(s):

Create different types of food chains.

Compare a balanced food chain to an unbalanced food chain.

Primary Grades (Kgn, 1st, 2nd, 3rd.)

Materials:

Peanuts in the shell or candy in a wrapper (hard candy) (approx. 150) of each.

Set-up:

Large open area – circle to start; may wish to break the class in half & work with one half at a time.

Strategy:

When you need energy in the morning before you come to school what do you do? Eat breakfast. Review that living things need food to give them energy. Plants get energy from sunlight. Grasshoppers get their energy from plants. Birds get their energy from grasshoppers. Draw the food chain on the board as you go along. Explain that this is a food chain. The plants and animals in a food chain depend on each other to live. What would happen if all the plants died? (Erase plants from board) Can grasshoppers get their food or energy from the sun? No. The grasshoppers would die. (Erase the grasshoppers) All the animals that eat/ depend on the grasshoppers would die too. So every part of the chain is important.

Today we are going to experiment with creating our own food chain. We are going to have the sun's rays (teacher and 3 students), some plants (16), some mice (11), some snakes (7), and some hawks (3). Break students into groups (suggestions: group by clothing – i.e. pick 16 people in green to be plants, etc). Have all the plants sit on the floor next to each other in a straight line. Behind them have the mice sit next to each other (facing the plants' back), behind them the snakes and behind them the hawks, (to form a pyramid) [Option: if space is limited have the plants create an outer circle, the mice inside, the snakes inside them and the hawks at the core.]

Explain that you and your 3 helpers are the sun's rays and that you have energy (peanuts in the shell) to pass out to the plants. Give each plant a handful of peanuts (at least 16). The plants should keep 2 peanuts (do not eat yet) and pass the rest to the mice behind them. Make sure you notice how many peanuts are handed to you before you pass them on. The mice should keep 2 peanuts and pass the rest to the snakes. The snakes should keep 2 peanuts and pass the rest to the hawks. The hawks should end up with a lot of peanuts. (Do not eat the peanuts yet).

Discuss how the chain worked (everyone got food – well distributed, the sun was the original source of energy, all the participants depend on each other). Who got the most peanuts? Why do the hawks need the most energy? (They are bigger, they need more energy to move and fly). Make comparisons between a big athlete like Shaq and a kindergarten student. Who would need more food for energy?

Collect all the peanuts and explain that now we are going to see what happens if the food chain is not balanced. This time there are no hawks because humans that were hunting killed them all. What that means is that since there were no hawks to eat the snakes we have even more snakes than before. Have all the hawks now become snakes and join that group. Start the chain as before, (Every student keeps 2 peanuts). What happened when we got to the snakes? Did each snake receive more food or less food than before from the mice? (Less) When there are too many snakes there is not enough food for them all and some will die of starvation. We need the hawks to balance the chain.

Collect the peanuts and put the hawks back in their spot. This time we had a bad drought and only half of the plants survived. Only give out peanuts to half of the plants (or half as many peanuts to all the plants) Keep the same numbers of students in the other groups. Continue the chain as before keeping 2 peanuts as before. What was different this time? Did everyone receive as many peanuts as they did the first time we did this? No. Some of the animals will die off because there isn't enough food for everyone, (hawks may not receive any peanuts).

Performance Assessment:

Students will fill in an observation chart or (make a chart) by choosing a food chain for each animal or plant listed in the lesson. (i.e. sun – corn-cow-humans).

-

Conclusions:

-

We can see from our experiment today that food chains need to be balanced. Now you can eat your peanuts.

References:

Kaleidoscope, Aid for Primary School Science Ed. Feb 92 Vol. 7 #5

Hands on Nature**, Vermont Institute of Natural Science, 1986**

Critters, **AIMS Education Foundation, 1989**

Science on the Go**! The Chicago Academy of Sciences**

Memory and Learning

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Objective:

The teacher will introduce primary students to the various parts of the brain and provide specific activities and a plastic model designed to help improve memory.

Materials Needed:

One gallon plastic water container (for each student)
A child's silhouette (for each student)
A drawing of a brain, that can be divided, into three puzzle pieces of the three science words below, (for each student)
Science Words, Medulla, Cerebellum, Cerebrum (for each student)

Strategies:

Activity One

Medulla

Teacher will ask three (3) volunteers to come up, close their eyes and put their hands behind their backs. Teacher will prick one with a pencil. The student should make an involuntary movement. Teacher will touch another student on the neck. Teacher will touch the other student lightly on the hand. The medulla is responsible for respiration, circulation, muscle tone, nerves, reflexes, and it controls all internal functions.

Cerebellum

Teacher will draw a line on the floor and ask a student to walk in a straight line while the class observes. The cerebellum is responsible for balance, muscular coordination and motor skills.

Cerebrum

Teacher will discuss students' various emotions. When students feel sad or happy, the cerebrum is stimulated. The cerebrum is also responsible for higher level skills and critical thinking.

Activity Two

Teacher will whisper a nonsense sentence to a student. The student whispers the nonsense sentence to the next student. This continues until every student has heard the sentence. "Cherry Berry is my favorite fairytale for toddlers" is a good choice. Rhyming and alliteration with the "F" and "T" sound help the memorization process even though the sentence is a nonsensical one.

Activity Three

Song to teach the Continents

When teaching a song, the medulla and cerebrum are at work. The medulla allows a person's muscles to perform in such a way that she/he can pucker so air can pass, thus forming the lips to sing. The cerebrum is responsible for the part that allows students to "know" the words and the tune to the song.

"Continents, continents, what are you?
Continents, continents, what are you?
Continents, continents, what are you?
You are a great big world.

A is Africa
A is Australia
A is Asia
A is Antarctica
E is Europe
N is North America
S is South America

You are a great big world."

This song is sung to the tune of any familiar nursery rhyme.

Activity Four

This song is sung to the tune of any familiar nursery rhyme.

"I know the five great lakes.
I know the five great lakes.
I know the five great lakes.
All I need to know is HOMES.

H is Lake Huron
O is Lake Ontario
M is Lake Michigan
E is Lake Erie
S is Lake Superior

All I need to know is HOMES."

Activity Six

Each student is given an empty one gallon water container and a silhouette of a child's head. They will color the picture, cut it out and paste the silhouette on the container. Each student will be given a "brain puzzle". He/She will match each puzzle piece with the original copy that they received earlier. Teacher and students will discuss and label the 3 (three) parts of the brain. When a child can say the vocabulary words and demonstrate an understanding of the functions of the brain, then he/she can place the words and brain parts into the brain (container). THEY CANNOT PUT ANYTHING INTO THEIR BRAINS UNLESS THEY CAN SHOW COMPLETE UNDERSTANDING. THEY MUST REALLY KNOW IT.

The container will be used for the entire year to collect data that the students have learned. The students can put the five Great Lakes and the Seven Continents into the brain (container). Students can also put math facts and times tables into the container. This is an excellent source of recall for students to use to review skills already learned. I emphasize reviewing the information in the brain (container) frequently to put knowledge into long term memory.

Assessment:

Student will demonstrate mastery of material in the brain through a periodic checking system set up by teacher. If student forgets material that he/she has already learned, he/she must take it out of the brain. This is an ongoing process. Checking can also be done by another peer. Peer tutoring is strongly encouraged.

Conclusion:

The knowledge that we have acquired as teachers and techniques for teaching it, if combined with what I believe to be a "true calling", is the greatest formula for becoming an effective, highly motivated educator.

Memory and learning go hand in hand. All students do not learn at the same rate, but all children can learn. Using different strategies and creating a safe and positive learning environment will enable students to learn and be successful.

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Cells Are Us

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Objectives:

(These objectives are suitable for K-3 grade levels.)

The main objectives of this mini-teach are to show that the cell is the basic unit of life; that cells divide slowly to become mass of cells (mitosis); and that there is a gradual loss of cells throughout life.

Materials Needed:

Cell Observation(s)
"Cells Are Us" song
paper
pencils
microscope
slides
slide covers
iodine
eye dropper
cotton swabs
water
long balloons
string
marbles

Cell Loss Observation(s)
(memory)
pencils
paper
shopping bag
various items to be used
for observation
index cards
envelopes
markers
"Hocus Focus" picture

Strategy:

Cell Observation
1. Distribute "Cells Are Us" song to class.
   Have class sing song which explains about mitosis.
2. Ask students to draw a dot on paper. Tell class: "This was you -- billions of cells ago."
3. Distribute microscopes. Have students:
   a. Gently scrape inside of cheek with cotton swab;
   b. Stir end of cotton swab in drop of water on a slide;
   c. Add a drop of iodine solution to color cells;
   d. Look at slide under microscope to observe skin cells.
4. Give each student two long balloons and string. Have students blow up one balloon and twist the ends in opposite directions to give an idea of what the first egg cell division looks like. They can also tie a string in the opposite direction (if the balloon doesn't burst) to show a model of the second division. Explain that the cells go on dividing.
5. Demonstrate how cells keep getting smaller and smaller, and become crowded for room. Show how they begin to arrange themselves into a ball, or sphere, with an open space in the middle because of their rounded shape.
   a. Take some marbles and push them together.
   b. Demonstrate how the marbles pack tightly if you use just a few.
   c. Add more marbles and you will find that they tend to arrange themselves around an opening left in the center.
   d. Explain how this process goes on and on and on.

Cell Loss Observation (memory)

1. Distribute "Hocus-Focus" picture to the class. Have students write down at least six differences that they see between panels.
2. Put 18-20 various items into shopping bag. Have the students observe as you name the items as you remove it from the bag. Have volunteers orally recall as many of the items as they can. The volunteer with the most correct responses may select one of the items as a prize.
3. Draw/write duplicates of various pictures and symbols on index cards. Place in two separate envelopes. Have students observe cards for one minute then write down the names of the items in the envelope.
4. Have students with color-coded cards work in pairs. Mix up and turn over the cards in both envelopes. Have students try to find and match like pairs.

Performance Assessment:

At the conclusion of the mini-teach, students will be able to answer the following questions:

1. What are cells?
2. Can you explain mitosis?
3. Why is cell division important?
4. What effect does aging have on mitosis?

Conclusions:

Students will understand that a cell is a tiny unit of life; the smallest "building blocks", from which all living things are made and that cell production slows as we age.

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Enquirer-type Newspapers Have Many Uses

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Objectives:

This lesson is for 2-12th grades. Using this high interest reading students will learn about animals, including humans and their care and feeding, photography and how to make false photos, critical thinking skills, weighing of evidence skills, research skills, the journalism techniques, citation exactness, increased judgment and scientific method skills, especially making conclusions.

Materials Needed:

Several Enquirer-type newspapers, especially the Star, Sun, and Weekly World. Try to read until you find at least one interesting article for the lesson you wish to teach. Some of these papers have 99% of their articles about movie stars only. Try for those that have a wide variety of articles.

Strategy:

Photocopy 6 copies of each article that you like. Assign groups of 2, 3 or 4 students to each article. They must read it and report on it for several integrated (interdisciplinary) purposes. For example, an article and picture about the (or a) Loch Ness monster being hoisted aboard a Navy ship may convince some students that this prehistoric animal does exist and that our government doesn't want us to know about it. A journalism assignment might be for one student to write out and report on the answers to the journalistic questions of "Who, What, Why, When, Where and How" as stated in the article. A research assignment might be to have a student make comparisons as to the features of dinosaurs as compared to the features shown in the photographs. Another research assignment might be to compare and graph the number of sightings over the last 500 years and to create graphs as to the population density so as to properly weigh the sightings. This could lead to a comparison of time spent in or near the lake (loch is the Scottish word for lake). Another research project could be on the invention of the submarine (by a teacher) for use by the United States Navy, who rejected the invention several times before finally accepting it.

Another assignment could be to look at the article and to write down the reasons other investigators gave to show how the witnesses were misreading what they saw due to light and cloud shadows on the lake, or mistaking a wave going over a log, etc.

As to the human animal their are many interesting articles, that bear more scientific inquiry to negate them or to expand them or to verify that their basic content accomplished what its author claimed in the title. For example in a recent article about possibly being a shopaholic, which was claimed to being addicted to alcohol or drugs or nicotine, if a person answers 4 out of 8 questions in the quiz given, the person should seek professional help before they make things worse by causing their own bankruptcy. An assignment could be to talk to and interview with written notes the school counselor as to whether this article seemed sociologically and psychologically sound and why or why not. If the counselor is a potential shopaholic, then have the school nurse or the school social worker interviewed.

The possibilities are endless. These short articles have such high reader interest, even your reluctant readers will finish them and give a report with high enthusiasm.

Now, feel guilt-free to indulge your urge to buy these magazines. They are to help your students read and more importantly to think clearer, and in a more scientific manner - to weigh probabilities and possibilities and to discuss future courses of action and additional study. Also, they are good for some humor too.

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Living and Non-Living

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Objective:

This lesson was designed for primary grades 1-3. The main objective of this mini-teach is to generalize that all living things need air, water, food and shelter.

Materials Needed:

Plant, wood, plastic, bird, hamster, turtle, crab.

Strategy:

1. Take the students for a walk around the school. Have each student make a list of all the living things they see.
2. Develop a game for the identification of living and non-living things.
3. Tell the pupils to bring a healthy plant to school. Do not water the plant for a week or two. Have the students observe what happens to the un-watered plant. Keep a class journal of what happened.
4. Tell the students to hold their breath for as long as they can. Record the amount of time each student holds his or her breath. How did you feel after this activity?
5. Have students explain different kinds of shelter used by humans. Ask them if all people need shelter.
6. Have students think of things that might destroy the good air at home or out-of-doors. (Answers might include smoking, pollution, strong odors etc.)

Performance Assessment:

1. How does something in the world qualify as a living thing?
2. What two groups can everything in the world be divided into?
3. What is an organism?
4. What are two differences between living and non-living things?

Conclusion:

At the conclusion of this mini-teach pupils will be able to tell that all living things need food, air, water and shelter in order to survive.

OUTSIDE ACTIVITY:

Write the name of all living things under the appropriate category.

Living Things	**Non-living Things**

1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

All living things have three general characteristics. What are they?

1.
2.
3.

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Freshwater Sharks Bite Children at 35th Beach. A Play

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Objectives:

This lesson is for 2-12th grades. Students will learn about the many different scientific occupations as well as some possible specializations therein, and perhaps a little bit of other life considerations, ecological, financial, educational, sociological, and emotional as to greed, avarice, truth justice and the American Way. It integrates biology, physics, drama, chemistry, genetics engineering areas, etc.

Materials Needed:

3x5 cards. That's all really. But, you are probably reading this on a computer so you will have to transfer the parts to 3x5 cards. Therefore you will need access to printer, scissors, and glue or a printer and laminator to print, cut and glue the parts of this play onto 3x5 cards or to just print or photocopy, cut and laminate this play.

Strategy:

Other than on career day it is hard to transmit the enthusiasm and thinking involved of a professional educated person pursuing their knowledge and their detective-like dedication in this full-run headlong pursuit. By putting these cards and more in the hands of students, each one will have a new and interesting part to play, will see a glimmer of how complex our ever increasing store of knowledge and our society is and will be motivated to want to make a more relevant concentration in their education.

The setting of the play is a sort of "town meeting" or in this case, a public meeting attended by the Chicago ward committeeman who is also a Chicago city building inspector, and other people in the neighborhood of the 35th street beach, 60% of whom are shouting that something has to be done to save "Our Children, Our Future" (which is the present motto of the Chicago Board of Education).

Be or appoint a moderator for this discussion. Tell the students that they must observe, take notes and write 1-5000 paragraphs on what is happening in this meeting what the thoughts are of the people there, what they said, where they are coming from, going to and what type of person they are, by writing a 1 paragraph character sketch of each person. They must write about 1-30 characters in the play.

Here are the parts to be glued on the front and sometimes back of 3x5 cards, or just laminated from the printed or photocopied page.

Pro shark. SHARKS NEVER HAVE CANCER AND THEY EAT EVERYTHING THAT CAUSES CANCER. In fact I have been FEEDING THEM CANCEROUS LIPS AND LUNGS removed from smokers and many human cancerous body parts removed by local surgeons as well as fish with cancer. I have injected live cancer cells into them and they never get it. As a microbiologist I think I HAVE FOUND ALL of the ANTIBODIES in a shark THAT PREVENT CANCER from growing. As a marine biologist I have been researching for these antibodies that their bodies make and I'm trying to synthesize them.

Pro shark. I am an Ecologist. The previous invasions of the lamprey eel and the zebra shell mussels haven't done any appreciable damage. Let's wait and see, the cures might pollute the water. In fact, the last invasion is clearing up not only the Great Lakes, but also the Mississippi River. And, it is providing a possible new food source, for certain fish, so the zebra mussels have proved to be very beneficial in the long run for water reservoirs, as free hardworking purifiers.

Pro shark. I am a cytologist. I have discovered how the shark's cells repel cancer. I feel I can clone these cells and inject them into humans to replicate and cure cancer. Like all scientists, I will need several freshly caught sharks everyday for the next five to ten years to finish my research.

Pro shark. I am a chemist and have found that sharks have a chemical in their body made near or in their (liver?) that keeps them hungry most of the time. My niece is very thin because of anorexia nervosa. If I can isolate and synthesize that chemical, I can sell it worldwide to doctors to treat that disease. I always wanted a mail order business that was a guaranteed moneymaker. More importantly, so does my wife. The mentally ill (neurotic) anorexic people will always be with us so our new business will be recession proof. The fisherman delivers daily.

Pro shark. I'm a physicist. I'm freezing different sharks, making molds of them and filling the molds with different liquid combinations to equal exact scaled down models made of real airplane materials of equal mass. I then suspend them in wind tunnels to test for a new jet design.

Pro shark. When night falls, I am the

fisherman. I know people are afraid of the sharks, and I catch them at night by using bloodball bait and nets and hooks that I have shot out with a crossbow at night. I come back just before dawn, haul in my catch, throw it into a large body bag in my trunk and await my calls on my cellular phone while I have breakfast at the IIT cafeteria. I am parked at the IIT lot across the street. I'm wondering about getting my lazy brother-in-law to do the same for Loyola, DePaul, Northwestern, U. of Illinois, and Roosevelt professors.

Pro Shark. I am a virologist and I have designed a virus to carry the all purpose virus I found in the freshwater sharks that keep them from ever getting ill. They never die from illness. They only die when bitten by accident in a feeding frenzy and then they are eaten by other sharks. I designed a human virus to carry this virus into human cells to take over the mitochondria and to make these protective viruses so humans will live longer or maybe forever.

I am a virologist and I have designed a virus to carry over the genetic cell design for reproduction of teeth to the human body so that we will keep growing new teeth and we will never ever have to see a dentist in our lifetime.

I am a chef and I have 67 proven recipes for shark fin soup, etc. I'm working on creating new ones and I'm writing them down so I can write and sell my cookbook worldwide.

I'm a marina owner and I have rented out 25 more spaces to charter boat captains. This is $50,000.00 extra income in boat rental dock and drydock fees, per year. I now spend the winter in Florida and let my son run it during winter arthritis time.

As a geneticist I've found a variant gene on chromosome 17 that is psoriasis susceptible causing cells to divide at a faster rate and never mature. I can see the normal development easier in a shark's cells and gain clues as to what is needed for normal growth.

As a Chicago licensing official whose brother-in-law is a building inspector. Boat owners, new restauranteurs, and commercial fishermen are pounding on my door with money in their hands. New hotels are going up on 35th street and they need liquor, food and other licenses. I own 4 vacant lots on 35th street.

Antishark. I am Sister Teresa and I run the Catholic orphanage on 35th street with 3000 children of wading and swimming age.

I'm a mother of 15 children, ages 1-15 and we live next to the 35th street beach. My children love to swim and sailboard there.

Pro or anti shark. I am Mrs. Know-It-All. I interrupt people, and say things like, "I know where you're coming from," and that "You scientists are nothing but educated fools," or "It's about time we had some meaningful research done once and for all and children should not stop progress, they should be in school all summer anyhow." WRITE YOUR OWN SPEECH AS QUICK AS YOU CAN. WRITE MORE IF YOU WANT TO.

Neutral. As an engineer in the Army Corps of Engineers, I'm in charge of the shoreline and all inland waterways including all rivers. If an underwater fence is put up by the beach to stop sharks from biting and eating parts of swimmers, it would cause many people to lose their lakeshore homes at the southern tip of Lake Michigan in Ill. and Ind. unless you spend $1,000,000,000.00 to build a jetty due east to prevent beach erosion. Your taxes will go up to pay for this.

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Food For Energy - Four Food Groups

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Objectives:

This lesson is designed for students in grades two through four.
1. Teach the students the importance of eating properly with a balanced diet.
2. Identify foods that belong in the Milk Group and the Meat Group.
   a. State and/or understand that most food in the Milk Group and the Meat Group come from animals.
   b. State and/or understand that foods from the Milk Group and the Meat Group give them energy.
3. Students will be able to state and understand that foods in the Fruit-Vegetable Group and Grain Group come from plants.
   a. Identify foods that belong in the Fruit-Vegetable Group and Grain Group.
   b. State and understand that grain is made into flour and flour is used to make bread and other grain products.
   c. State and understand that foods from the Fruit-Vegetable Group and Grain Group give them energy.
4. Know where various foods come from and that animals eat plants.

Materials Needed:

Food Chart
Cut Pictures of Food
Index Cards
Glue
Food Triangle
Flannel board and velcro
Zip Lock Bags
Popcorn and Popper
Butter
Variety of foods from each food group:
- Loaves of long Italian or French bread
- Pound of 3 different types of sliced meat (roast beef, turkey, ham, salami, bologna, etc.)
- Pound of 3 different cheeses (American, Swiss, Cheddar, etc.)
- Tomatoes 2
- Lettuce 1
- Oil

Crayons
Scissors
Ice
Rock Salt
Milk
Sugar
Vanilla flavoring
Salt
Plastic Gloves

Strategy:

1. Have the students jump, blink their eyes, clap their hands.
2. Ask each student how the body is able to do these things.
3. Introduce the concept that food produces energy, and that is how we are able to do activities such as running, etc.
4. Introduce the Milk and Meat groups.
5. Show food cards from each group and ask where these items come from?

6. The students will say that most of the Milk and Meat groups come from animals.
7. Have the students wash their hands.
8. Explain why it's important to wash our hands when we are handling food.
9. Make ice cream which is a food for energy.
10. Give each student a small Zip Lock Bag, and plastic gloves for their hands.
11. Add 4 ozs. of milk, three teaspoons of sugar, and 1/4 teaspoon of vanilla flavoring, then zip the bag.
12. Take a gallon size Zip Lock Bag add 2 cups of ice and 1/4 cup of rock salt, place the small zip lock bag into the larger Zip Lock Bag with the ice.
13. Shake the bags; make sure the inside bag stays closed and sitting upward.
14. Shake the bags until you have ice cream. Then remove the small bag and eat the ice cream.
15. While eating the ice cream, review and discuss how we get proteins, and other nutrients from milk and meat, also why they are energy foods. Talk about the exception to this group (legumes).
16. Next, we'll introduce the Fruit/Vegetable group and the Grain group of food.
17. Show food cards from each group and ask where these items come from.
18. The students will say that most of the Fruit/Vegetable group and the Grain group come from plants.
19. Discuss each group and the nutrients received from each group.
20. Have the students wash their hands.
21. Now we are going to make popcorn.
22. Measure 1/4 cup of popcorn and place in the corn popper.
23. Place butter in the top while popping the corn.
24. Add salt and pass the popcorn around to each student.
25. Discuss the value of the Fruit/Vegetable group and the Grain group.
26. Show how these groups are used for energy.
27. Next, we'll introduce the combination groups.
28. Discuss the foods that belong in the combination groups such as pizza, and sandwiches, etc.
29. Have the students wash their hands.
30. Each student will make a sandwich using a variety of meat, cheese and vegetables.
31. While eating, review and discuss the four food groups and the combination group and how they are used for energy.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following question regarding these topics.

1. Why we need energy in our body: for breathing and various exercises?
2. Energy is measured in units called calories.
3. Food contains various nutrients such as protein, carbohydrate, and fats.
4. Students can identify foods that belong in the Milk and Meat groups.
5. Understand that food from these groups comes from animals.
6. State that energy comes from these two groups. (Milk and Meat)
7. Students can identify foods that belong in the Fruit/Vegetable and Grain Groups.
8. Understand that food from these groups comes from plants.
9. Students will be able to classify foods into the Four Food Groups.
10. State that energy comes from these two groups. (Fruit/Vegetable and Grain)
11. State and understand food preparation safety rules.
12. Help prepare a Combination Food.
13. Know the importance of a balanced diet.

Conclusion:

Students will know the Four Food Groups and understand the importance of a balanced diet. They will also know the importance of food preparation safety, and will understand how quickly bacteria multiply.

References:

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Classification

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Objective:

The students will observe various apples, contrasting them, and classifying the apples based on structure and color.

Materials needed:

Different kinds of apples:

Red Delicious, McIntosh, Granny Smith, Golden Delicious, Rome Beauty

hand lens
ruler
plastic knife
paper towels (for clean-up)

SAFETY TIP: Advise students to use EXTREME CAUTION with the plastic knives.

Strategy:

1. For co-operative groups of 3-4 students.
2. Give each group a basket of apples, different colors, various sizes, stems, without stems, etc.
3. The groups' project will be to show how the apples are alike and how they are different. The groups will categorize the apples into as many categories as possible. (By sizes, color, stems vs. non-stems, etc.)
4. Give each child a hand lens to look through. Invite each child to closely observe the apples' skin color. Discuss. Compare and contrast.
5. Have the students cut each apple through the center. Measure the diameter, record. Observe the texture of each apple inside and outside the apple. Record.
6. Have the students look for the seeds. Are the number of seeds in each kind of apple the same? Are more seeds found in any one kind of apple? Record.
7. The groups will be able to compare seeds, if the number of seeds are different. Data can be graphed.

Performance assessment:

Students will be able to tell how apples are alike and different.

Curriculum Connection:

LANGUAGE ARTS/ARTS Have students draw pictures of their favorite apple, then have them write a descriptive paragraph telling how the apple looks and smells.

MATH Have students draw an apple to scale. Students can measure diameter and circumference of the apples and graph the results.

POSTER Students can use the poster "parts of an apple" and be able to

identify parts of an apple.
LITERATURE Students will read selected books relating to "The Apple".

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A Biology Game To Promote Classification And Observation

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Objectives:

Students should learn to observe with an eye to noticing differences and salient characteristics. Also students should be able to communicate these observations in a brief manner.

Materials needed:

A wide selection of specimens from the lab's collection were used but in ordinary classroom situations any found objects would be useful.
Enough 3 by 5 cards for the class.

Strategy:

Each student is to have a specimen jar in front of them at start of class with a 3 by 5 card. They examine the specimen very closely. They are next asked to write down a careful description of the specimen on the card. When this has been completed students will hand in their cards. The instructor will mix up the cards and then pass them out to the class again. The students will read the cards and then try to match them to the specimen.

Performance assessment:

For each individual student, performance can be measured by the success they have in matching their card to the appropriate specimen. Overall class performance should not be less than 90%.

Conclusions:

Students will need to observe their specimen and very carefully note those characteristics which are significant and may not be confused with the other specimens. Students that have difficulty matching their cards will learn what they would need to do in order to make their description clearer. It will also be seen that a system for describing organisms needs to be succinct and less cumbersome. Again, this is an exercise that points out the need to classify and how to go about it in a way that will enlighten rather than confuse.

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Introduction to the Scientific Method

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Objectives:

The main objective of this lesson is to get the students involved in a class activity while introducing the process of the scientific method.

This lesson may be used on any grade level. It may be used as just a problem solving situation or as a beginning class activity.

Materials Needed:

String - One piece per person (about 3 feet long)

Strategy:

1. Divide students into groups of two.
2. Each student should tie the ends of their string into loops (big enough to put their hands into loops but small enough that the string will not be continuously falling off).
3. One person from the pair should place the string onto his/her wrists such that it resembles handcuffs with about two feet of string in between each of their hands.
4. The other member of the pair is to place one loop around one hand only. They are to then take the string and place it between their partners' body and their connected hands. The student should then attach the other end of their string around their other wrist (see diagram 1).
5. The students should now be connected such that they must devise a plan to separate themselves from each other without removing the string from around their wrists.
6. You should then have the students write out their ideas on what they believe would be the best way to solve this problem using the first two steps of the scientific method. (State the Problem and Form a Hypothesis)
7. Now using the third step (Testing the Hypothesis) the students are to try to untangle themselves by the methods they devised when forming their hypothesis.
8. After giving the students ample time to try to test their hypothesis they are to finish their scientific method by either accepting or rejecting their hypothesis and forming a conclusion.

Performance Assessment:

As stated above the students are to write out for themselves how they are going to solve the problem using the scientific method. Another problem may also be given to the student such that they are to try to solve the new problem using the method they just learned.

Conclusions:

It may be nice if you are able to show the students how to get separated from one another since most of them will be unable to do so. The main trick is that you do not need to move yourself around at all which most of the students will find themselves doing (suggestion: tell the girls in the class that are wearing skirts or dresses that they will be unable to do the lab - this leads the students to believe that they have to manipulate their bodies in many different directions). All that needs to be done is for one of the students to rotate their hands such that the string is perpendicular to their partners. They are to take the half of the string which is in the upper half and note which hand it is closer to on their own body. They are to take that half and loop it through their partners wrist loop on the opposite hand of their partner (if the string was closest to their own left they are to go through their partners' right). The loop should be pulled through the wrist loop in the direction of the person's fingertips. Once the loop is pulled through the wrist loop it is to be pulled over their partner's hand. The student should then be able to extract themselves from their partner by moving the string off to the side (see diagram 2 on the next page). If you try to do this and have any problems in solving it, feel free to call me.

In the following diagrams assume that you are person 1 and that you are standing with your hands up, palms facing you.

Diagram 1
The following diagram shows the initial positions of the two students and their ropes:

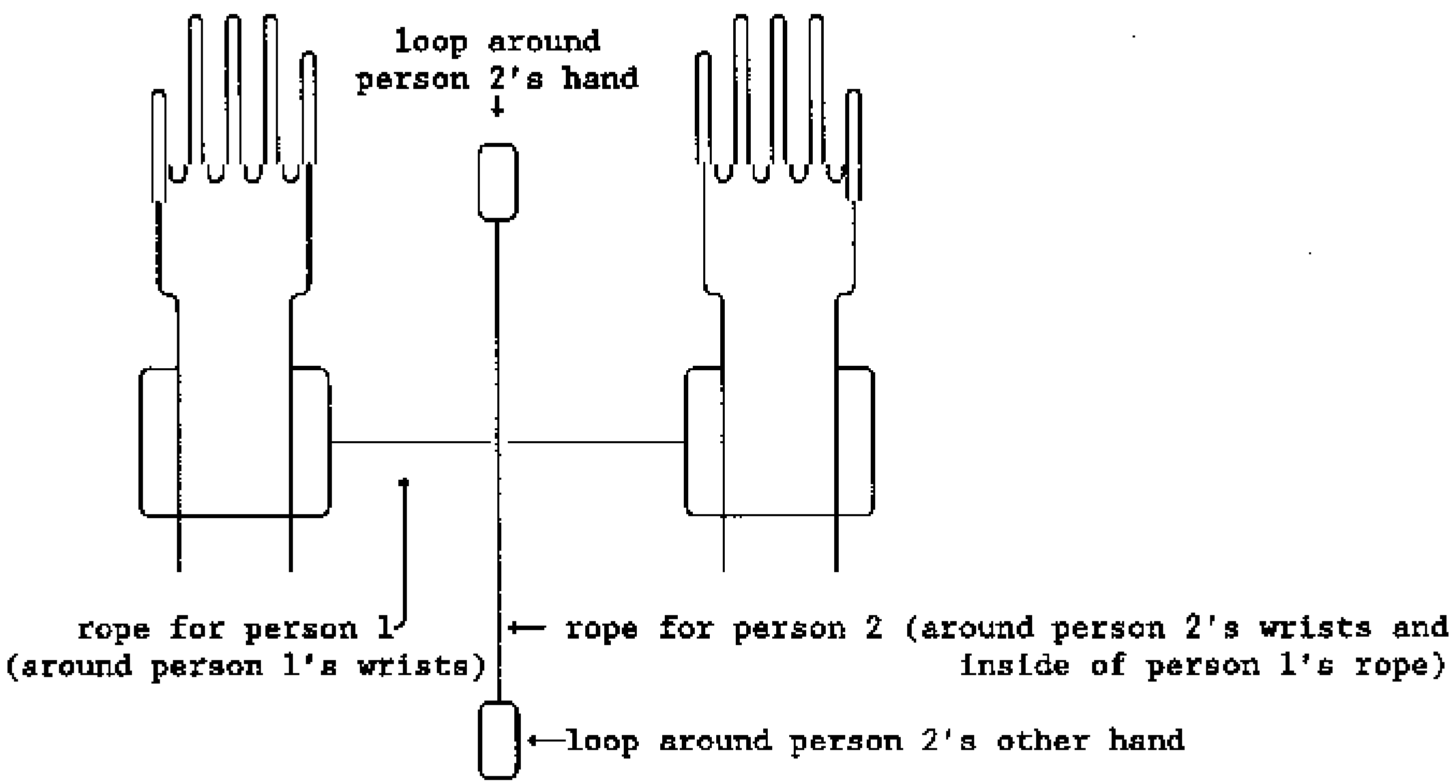
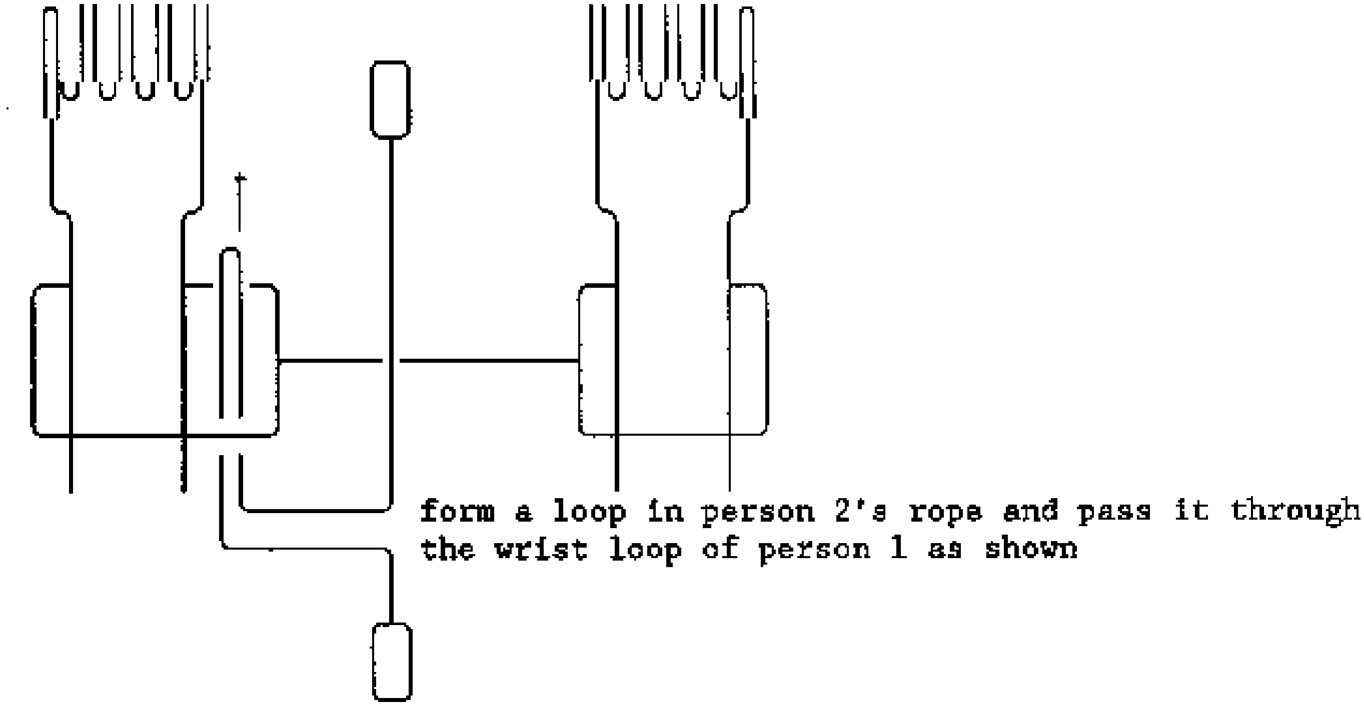


Diagram 2
To 'untangle' themselves, form a loop in the rope from person 2 and pass it through person 1's wrist loop as shown below:



Finally, pass the loop from person 2's string over the hand of person 1.

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A Demonstration of Photo- and Geotaxes in nauplii of Artemia salina

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Objectives:

This presentation was designed for High School students, but can be modified for use in Middle School. Students are presented with an easily observed orientation behavior of small crustaceans with respect to light and gravity, given some description of the habitat and feeding behavior of the organisms and encouraged to relate the phenomena observed to the needs of the organisms in terms of adaptation.

Materials Needed:

- 1 plastic shoebox with lid.
- 1 or 2 liters of 4% NaCl.
- A vial of brine shrimp (Artemia salina) eggs.
- 1 siphon, consisting of a two foot length of india rubber tubing with six inch segments of glass tubing inserted in each end.
- 2 wire pinch clamps
- 1 one liter flask (a clean milk carton will do).
- 1 100 ml. graduate cylinder.
- 1 approx. one cm internal diameter glass tube, about eight inches long.
- 2 black rubber stoppers to fit above tube (Size 00).

Procedure:

Hatching of brine shrimp eggs.

Brine shrimp eggs are available from tropical fish dealers. Purchased in quantity (1/2 to 1 lb.) from a biological supply house such as Carolina Biological Supply or Ward's Natural Science Establishment greatly reduces the unit price. Each egg is as small as a grain of fine sand. A teaspoonful contains many thousands of eggs. The eggs will remain viable for several years if kept cool and dry. If placed in a 2% to 4% salt solution the eggs will hatch into tiny larvae (known as nauplii---singular = nauplius). Do not use iodized salt, nor reagent grade salt; best results are obtained using sea salt, which is usually available in the gourmet section of your supermarket. A 4% salt solution is easily made up by making a saturated solution (add about 8 ounces of salt to two cups of water in a quart jar, agitate vigorously, and allow excess salt to settle), and diluting 100 ml of the saturated supernatant solution to one quart with water. (If you use tap water, allow it to stand overnight before use to get rid of the chlorine it has been treated with.) The best way of obtaining nauplii free of unhatched eggs and dead larvae (large numbers of eggs do not hatch, and many more die within minutes of emergence from the egg), is to fill a transparent plastic shoe box with 4% salt solution to a height of 1 to 11/2 inches, raise one end of the box about 1/2 inch by placing a wedge under it, so that the depth varies as it does in a swimming pool, and sprinkle about 1/2 teaspoonful of dry eggs over the surface. If this is done gently, the eggs will float on the surface. Penetration of the salt solution into the eggs initiates development. Oxygen is required, and this is obtained directly from the air by the floating eggs. At room temperature, nauplii will emerge about 36 hours after wetting; at 30 degrees centigrade, emergence time is about 24 hours. If the boxes are not disturbed during this period, unhatched eggs remain on the surface and the rapidly swimming nauplii are found in the solution. These can be separated by siphoning the bulk of the solution into a beaker or other container. After a short time, the nauplii will sink to the bottom of the vessel (this behavior is called a positive geotaxis) and a concentrated suspension of them can be made by transferring them to a test-tube by means of a dropper pipette.

Demonstration of Phototaxis:

Stopper one end of the glass tube and, holding the tube vertically, transfer the concentrated suspension of nauplii to the tube. Fill to the top with salt solution and stopper the upper end in such a way as to exclude all air bubbles. This can be done by holding a fine pin in the open end of the glass tube while introducing the stopper. The pin distorts the stopper and provides a pathway for excess solution and air to escape when the stopper is pushed into the tube; if the pin is then carefully pulled out (holding the stopper in place), no air bubbles will be trapped in the tube. Invert the tube a few times to spread the nauplii evenly and place it on a horizontal surface. Direct the light from a penlite flashlight on one end of the glass tube and cover the remainder of the tube with a paper towel. After a few minutes, almost all of the nauplii will be found at the lit end of the tube. If the opposite end of the tube is then illuminated, the nauplii will again move to the illuminated end. (Because of reflections of light in the glass tube, not all the nauplii move to the point of greatest illumination; some will remain in the body of the tube. If a round bottomed test-tube had been used for this demonstration, a large number of nauplii would be found at the center of curvature of the semi-spheroidal part of the tube. This is because the bottom acts as a crude lens, concentrating the light at its focal point.)

Questions For General Discussion:

Beside the light gradient, what other gradients might be present in the tube? (Gravitational gradient, chemical gradients of oxygen, carbon dioxide, excretory products of the nauplii themselves.) In what ways did the experiment try to minimize the effects of these other gradients? (Equal distribution of artemia at the beginning of the experiment, horizontal light gradient compared to vertical gravitational gradient, exclusion of air bubble.) Of what use is this built-in response to the nauplii? Why does the unpurified seasalt produce better yields of nauplii than purified table salt or iodized salt?

Background:

The brine shrimp lives in salt swamps such as those often found inland of the dunes at the seashore, in man-made evaporation ponds used to obtain salt from the ocean, and in salt lakes such as those found in the intermountain desert region of the western United States. (Multicultural note: large salt water lakes are found in many parts of the world; One of the larger of these is the Caspian Sea, into which the famous Volga River flows.) Few other organisms can tolerate such a high concentration of salt as is found in these locales. Sea water varies from about 2.9% to about 3.5% salt, depending on the latitude and the time of year. The Great Salt Lake, in northern Utah, undergoes long term variations in salt content, but since records have been kept it has varied erratically between 25 and 35%. Adult brine shrimp can tolerate a salt content of as much as 50%. Since few organisms can grow at such high concentrations as that found in the Great Salt Lake, brine shrimp from this locale do not have much selection in the way food. They live almost entirely on the photosynthetic green alga (singular of algae) Dunaliella. Like many other primitive aquatic plants this organism is attracted to light, rising to the surface in the daytime, and sinking at night. The positive phototaxis of Artemia keeps it at the same depth as its prey.

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Nutrition

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Objective:

To identify and describe the main nutrients in our diets that are needed by the body as a source of energy.

Materials Needed:

Grocery Store Ads, Overhead Projector, Chalkboard, Scissors, Markers, Graph paper, Pictorial Examples of Food, Food from actual stores.

Strategy:

1. Review vocabulary terms: cell, nutrient, food, diet.

2. Name (through the brainstorming process) some foods eaten the previous day. Predict how they can be grouped: Meats, Grains, Fruits and Vegetables, Milk Products.

3. Observe chart of food groups from overhead transparency.

4. Classify foods into groups from grocery store ads. Students work in groups of four. Place foods on individual charts.

5. Play "Nutrition Bingo". One student holds up a picture or object of food. The other students place markers on cards until a few bingos have been won.

6. Construct a chart of what they ate for their last two meals. Work in groups of two.

7. Graph a class chart of one meal eaten as a composite of each group of two according to food groups.

8. Examine food labels from four or more different foods. Chart information regarding the content. Categories are: Protein, Fat, Carbohydrates (sugar and starch), Vitamins and Minerals.

9. Compare and contrast results collectively during a "share time" discussion.

Conclusion:

Students will be aware of the necessity to eat a well balanced diet.

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Biology Trivia Questions

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Please note that students are to use their Internet resources to find the answers to these questions.

1. Are all invertebrates cold blooded?
2. What is the difference between a toad and frog?
3. How many heart chambers does a crocodile have?
4. Is the toad becoming more reptilian?
5. How many eyelids does a camel have?
6. Is the sun getting larger or smaller?
7. The fire ant has many enemies (true or false).
8. All insects live inside a hard skeleton (true or false)?
9. The name "Amphibians" comes from the Greek word which means what?
10. What organ needs the most energy, the heart or the brain?
ll. A Cuban Land Crab can outrun a horse (true or false)?
12. Is a rabbit a rodent?
l3. How many kinds of insects die after stinging only once?
14. Is a Giant Panda a bear?
l5. Why would you want to change an organism's DNA?
l6. Why are we in the primordial ooze?
17. Name the nut that is used in the manufacturing of dynamite.
18. Name the most popular green vegetable in the world.
19. Name the only food that lasts and does not spoil.
20. Primitive man used butter as what?
21. Name the largest tree on earth.
22. What is the difference between a physical change and a chemical change?
23. Which cells have DNA, white blood cells or red blood cells?
24. Define genetic engineering.
25. What is the significance of Morton's salt slogan "When it rains it pours?"
26. Is a Mandrill a baboon?
27. What is the purpose of a Punnett square?
28. Do all animals with two chambered hearts live in the water?
29. How many chambers does a fish's heart have?
30. Why does one become thirsty after eating salty foods?
31. Explain the story of Typhoid Mary.
32. Which is older, a bacterium or a virus?
33. This age is the age of electricity. What will the next age be named?
34. List three traits of a bird.
35. List three organisms that belong to the Arthropod Phylum.
36. Name the phylum of organisms that have spiny skin.
37. All fungi are producers (true or false)?
38. Digestion starts in the ___________?
39. Why do the left and right sides of the heart seem backwards in drawings of the heart?
40. Seaweed is used to make many products - name five.
41. White cells increase in number during an infection (true or false).

42. Nasal sprays contain a drug that _______ the capillaries in the Nose?
43. If your nervous system is slowed you become ____________?
44. In what ways are plants sexy?
45. Is a tomato a fruit or a vegetable?
46. Name a plant leaf which, when placed in soil or water, grows into a new plant.
47. Name three plants that can reproduce asexually by their stem.
48. Elephants develop for almost two years before they are born (true or false).
49. Name two sex cells.
50. Name the disease where blood cells do not carry enough oxygen.
51. Which type of behavior can be changed, innate or learned?
52. Armadillos are reptiles. (True or false)
53. Name the phylum of animals that have baggy bodies.
54. List some medicinal uses of cocaine.
55. Who is "Typhoid Mary"?
56. Jean Harlow, an actress, died as a result of what?
57. How many stomachs does a cow have?
58. Why do women menstruate?
59. Do porcupines shoot their quills?
60. Julius Caesar and Napolean Bonaparte were born with ________?
61. Name the largest creature on earth.
62. What type of bird is one likely to find in one's backyard?
63. Which bird has two toes in the front and two in the back?
64. Distinguish between a jungle and a forest.
65. How does one distinguish a baby Parakeet from an adult?
66. Are mealworms "true" worms?
67. Name the largest muscle.
68. How are ticks related to crayfish?
69. What is the order of succession in a forest?
70. If you were walking through a canyon, which plants would you expect to evolve first?
71. What are the functions of the following laboratory equipment: a beaker, a funnel, a watch glass, a wire gauze, a ring stand and an evaporating dish.

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Biology Trivia

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Objective:

(Grades 2-10) To determine if you can answer the following questions.

l. Name the smallest bones in the body.
2. How many muscles are in the body?
3. The word hormone is derived from a greek verb meaning?
4. Is there a difference between a hare and a rabbit?
5. What is the purpose of a formula?
6. Distinguish between an autotroph and a heterotroph?
7. Name six types of sponges.
8 Who is Dr. R.E. Grant?
9. Write the plural for of the following words: Genus, taxon, paramecium, fungus, bacterium, thallus, phylum, octopus, apparatus.
l0. Name the uses of carbon dioxide.
ll. If you blow into a test tube of bromothymol, what happens?
12 How many types of sharks are there?
13. Most sharks are dangerous to people? True or false?
l4. How many rows of teeth does the shark have?
15. Does the shark always have a supply of teeth?
16. Do sharks have bones?
l7. If sharks stop swimming, what will happen?
l8. If a shark is in still water, what will happen?
19. What are the pores on the shark's snout for?
20. A baby shark is called?
21. What is a feeding frenzy?
22. What is so unusual about the Thrasher Shark?
23. Name the Shark's only enemy.
24. Name the predator that has no natural enemy.
25. Why do fish give off a glow, especially in the very deep waters.
26. Name the animal with the largest teeth in the world.
27. How does the elephant help man?
28. Which are older, the sharks or the dinosaurs?
29. How can one protect themselves from a shark?
30. Name the shark that regularly eats dolphins, sea lions, whales and people.
31. Are planktons solely tiny plants?
32. If one boils a maple leaf for an hour, what colors will one see?
33. Does an acid solution have an excess of hydrogen ions?
34. As one grows older, what happens to one's bones?
35. Most people have at least 25 moles. True or false?
36. White Sharks never get sick. True or false?
37. Do all types of dogs belong to the same species?
38. Whose skin is thicker a man's or a woman's?
39. How come you gain weight when the temperature drops?
40. Which snakes are larger, male or female?
41. Do toads have teeth?
42. How does one determine the weight of one's skin?
43. What is a "Dactylogram"?

44. The word "autopsy" comes from the Greek word meaning to?
45. What is the word toad an acronym for?
46. What weighs more your skin or your brain?
47. What "killed off" the DoDo Bird?
48. Do deaf people get seasick?
49. Male canaries sing. True or false?
50 Name the oldest living thing.
51. How comes nobody gets a headache and a toothache at the same time?
52. Do kangaroos live in trees?
53. Ron is undergoing a "rhytidectomy". Explain.
54. What's the longest street in Chicago?
55. Can whales roll their eyes?
56. What is a group of turtles called?
57. What is a gnathologist?
58. Female Aphids aren't born pregnant. True or false?
59 What fish has no brains?
60. What is the purpose of a baleen?
6l. Is a whale eyesight good or bad?
62. Name some plants and animal plankton.
63. What is a manatee?
64. Why is a food chain important?
65. What is a scaffold?
66. How many days does a human pregnancy consist of?
67. What fish has no brains?
68. What is the purpose of a microscope?
69. List the characteristics of a mammal.
70. Is DDT harmful to all living things?
71. Name the oldest living thing.
72 List several biodegradeable products.
73. How many stomaches does a cow have?
74. Why do some farmers make their cows swallow magnets?
75. What is a trait?
76. Why study science?
77. Draw a water flea?
78. Who is Gregor Mendel?
79. List fifty organisms.
80. What is the purpose of punnett square?
81. Name the tallest animal in the world.
82. Where does rubber come from?
83. List twenty examples of matter.
84. List the ten body systems.
85. What do water, ice, and snow have in common?
86. List several materials that are often recycled.
87. What is an immune system?
88. List twenty-five insects.
89. How do fungi reproduce?
90. Name the five kingdoms.
91. What is the purpose of ozone?
92. What is a petri dish?
93. What is a semiconductor?
94. Who was the first person to write about ecological phenomena and to introduce concepts to scientific literature?
95. What is the difference between a globe and a map?
96. A dried grape is called what?
97. List the uses of flowers.

98. Is a bee warm-blooded?
99. Name two types of reproduction.
100. If both parents have brown eyes, can an offspring have blue eyes? Explain.

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The Characteristics of Living Things

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Objective:

Grade Level 8

1. The students will identify the characteristics of living things using the method of observations.
2. The students will use recall to place visual data in proper order.
3. The students will transfer common names used to explain characteristics of living organisms to their scientific name.
4. The students will retain the structure of organisms through role playing.
5. The students will observe an exhibit using the overhead projector and explain on paper what they observed using the scientific process.

Material needed:

an overhead projector
a culture dish
a bottle of Duco cement
a bottle of red nail polish remover
a small rock or stone
pictures of a cell, a tissue, an organ, a system and an organism.

Strategy:

The students studied living things in seventh grade. They have seen a film this week. Today we will review the characteristics of living things. Place on the chalkboard/wall the following: a poster with the names of the systems and their functions with a cover for the name of the system. The processes and functions of all living things. Place all other posters on your desk.

Review the cell theory. Ask students questions about living things and record the answers on the board, **accept** all answers. If they need stimulation ask questions. Examples-How are living things classified? What do living things do? How can you determine when something is living? What is an organism? Can you prove you are one? Leave on the chalkboard, tie in later. Review cells, tissue, organ, systems and organism. Now have students take out pencil and paper observe on the overhead projector the following: 3 dishes about one-half full of water. The following will be placed in each dish: a stone, 3 drops of nail polish and two or three drops of Duco cement. The students will observe and write their observations. Now discuss. Return students to the chalkboard and place the things we noted on the chalkboard in the proper category according to the scientific processes all living things do.

Game:

Divide the students into two groups. One student from each group will pull a card to see who will be first, 3 points will be given for correct answer. If a student needs assistance from the teacher the group will receive 2 points. The opposing team may steal if they cannot answer for one point. One person from the group will draw and the group may give only one answer. The group must answer in one minute. Continue the same procedure as above. This is good way to help students retain data and enjoy doing it.

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Watercycle

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Objectives:

Grade level 3

To become aware of the natural circulation of water from oceans, lakes and rivers by evaporation into the air.

To know that condensation occurs to produce rain falling to the soil, running off to rivers, lakes and then to the ocean once again.

Materials Needed:

A teakettle, about 18 inches of tubing, a clear glass bottle with a narrow neck, ice, a pan large enough to contain both the bottle and ice water, and a heat source. **NOTE**: These materials should be used by the teacher.

Strategy:

1. The lesson will begin with a review of cloud formation. The science textbook has stated that clouds are made up of tiny drops of water. Our experiment will help to prove this fact. On the chalkboard there is a chart naming and defining some of the clouds: cirrus clouds, cumulus clouds, stratus clouds, and nimbus clouds.

2. There will be a discussion of the three steps in the water cycle:
evaporation, condensation and precipitation.
The sun causes water to **evaporate**. The moisture meets colder air and **condenses** forming clouds. When droplets in a cloud are too heavy the water falls to the earth as **precipitation**.

3. Do the following experiment:
Pour a pint of water into the kettle and attach the tubing to the spout of the kettle as airtight as possible.
Place the other end of the tube in an empty bottle.
Place the bottle with the tube in a pan, pack ice around the base of the bottle.
Boil the water in the kettle until you see a few drops of water collecting inside the bottle.

Conclusions:

The energy from heat speeds up water molecules and some move so rapidly that they evaporate or escape into the air as gas or water vapor. As more molecules rise they push into the tubing and pass through it to enter the bottle, which has been cooled by the ice. At that stage the cold air slows down the gaseous water molecules and they come together or condense, once again returning to the liquid state.

On earth there is a natural circulation of water from oceans, lakes and rivers by evaporation into the air. Then condensation occurs to produce rain falling to the soil, running off to the rivers, lakes and then to the oceans once again.

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Diffusion

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Objectives

After the completion of this lesson, the student will be able to:
1. Understand the movement of liquid molecules in a solid
2. Explain how molecular weight affects diffusion rates.

Equipment and Materials

Agar
Petri dishes
Number 5 Cork Borer
Dropper
Marker pens
Overhead projector

Chemical solutions of:
- $AgNO_3$
- NaCl
- KBr
- $K_3Fe(CN)_6$

Recommended Strategy

Demonstrate movement of molecules by (1) opening a bottle of perfume in one corner of the room and later observe the odor, (2) adding several drops of food coloring in a large beaker of warm water and later observe, (3) adding several sugar cubes in a large beaker of water and later observe. Elicit from the students the conclusion that: (1) molecules move because of some force and (2) molecules move from areas of greater to lesser concentrations.

Before class, pour boiled agar into several Petri dishes to a depth of 4 mm, cover and allow to cool and solidify overnight. Punch four holes, l5 mm apart, in agar surface by using a #5 cork borer. Remove each agar plug from borer before making another hole.

Obtain 1N solutions of these chemicals: $AgNO_3$, NaCl, KBr and $K_3Fe(CN)_6$. Number the holes then add several drops of each solution to separate holes. Do not allow them to overflow.

After several hours, observe the movement patterns of each chemical. Calculate the diffusion rate by measuring the distance/time. Then compare the diffusion rate of each chemical based on molecular weight.

In some instances, bands will appear at the interface of different chemicals representing a precipitate. Other color changes may result over longer periods of time, due to dilution and equilibrium.

Variations in this demonstration can include:

l. Comparing agar dishes that were refrigerated versus room temperature. Also, changes that occur as the colder dishes become warmer.

2. Comparing various chemical mixtures (e.g. dyes, inks) to determine the different diffusion patterns.

3. Comparing Agarose (a clearer compound) with nutrient agar using similar chemical compounds.

4. Placing the agar plugs in stacks in an agar base and apply different chemical solutions to determine the rate of diffusion and vertical diffusion chromatography, then the lateral diffusion across the plate.

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Biology Trivia

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l. Are all invertebrates cold-blooded?
2. Name the organism that has teeth as strong as steel, has no natural enemies & will never catch cancer?
3. Do fish have eyelids?
4. What is the difference between a crocodile & an alligator?
5. Name the largest animal on earth?
6. Do snails breathe?
7. Does a fungus have a stomach?
8. What animals besides birds lay shell covered eggs?
9. Name the largest organ in the human body.
10. Name the largest muscle in the human body.
11. Can a person whose stomach has been removed digest food?
12. How does carbon monoxide affect the body?
l3. How does the body rid itself of hormones?
l5. Are all humans born with 206 bones? Verify your answer.
16. Which is larger a centimeter or a millimeter?
17. What is a cloud called at ground level?
l8. Where does rubber come from?
l9. A dried grape is called?
20. What is Cannabis sativa?
21. Do birds have teeth?
22. What is rigor mortis?
23. The numerous amount of joints are located(on the human body)?
24. Is a spider an insect? Verify your answer.
25. Are armadillos reptiles?
26. The tallest animal is?
27. Why do some farmers make cows swallow magnets?
28. The study of plants is called______________?
29. Which is smaller an atom or a quark?
30. How could you quickly tell whether a cell was a prokaryote or a euckaryote?
31. State the difference between osmosis & diffusion.
32. Why is ATP important?
33. What is a hermaphrodite?
34. Name the dog that has a black tongue.
35. What is the symmetry of an ameba.
36. State the difference between a habitat and a niche.
37. Name the slowest bear.
38. What is a goiter?
39. Digestion begins in the ______________?
40. True or false: corn is a flower?
41. True or false: all flowers have 4 parts?
42. Name an animal knights used to pad their armor.
43. Why do dogs dig up bones?
44. Is the frog becoming more reptilian?
45. Why do toads bury themselves in mud?

46. If you saw a single organism in the water, how could you tell if it was a frog or a toad?
47. True or false: the human digestive system is about 90 feet long.
48. True or false: there are more bones in the neck of any bird than in the neck of a giraffe.
49. The study of birds is called?
50. What is the purpose of a crop (in birds & worms)?
51. What is a life span of a fly?
52. True or false: there are 500 different kinds of fleas alone.
53. Describe carbon dioxide as a solid.
54. Name the smallest bird.
55. Can an entomologist, with his expertise, determine how long an individual has been dead?
56. List three ways frogs breathe.
57. If frogs have lungs, how can they remain under water for long periods of time?
58. Why was the bison very valuable to the Indian?
59. What advantages do multicellular organisms have over single celled organisms?
60. What are lichens?
61. Why is the mitochondria referred to as the"power house"of the cell?
62. A person's arm is lacerated. How does one know whether an artery or a vein has been severed?
63. Can all animals with eyes see colors?
64. Is hair alive?
65. How many legs does an arachnid have?
66. Before injecting xylocaine into a patient's jaw, the doctor hides the needle. Is this an example of positive or negative reinforcement?
67. What is tetany?
68. What is meant by "survival of the fittest"?
69. Why should a mountain climber be concerned about a "build up" of lactic acid?
70. True or false: all organic substance contain carbon.
71. Differentiate clearly between breathing and respiration.
72. Why is the sea blue?
73. Why aren't there sharks in Lake Michigan?
74. True or false: the weasel and the ermine are the same animal?
75. True or false: there are 10 different kinds of rice.
76. Distinguish between a dwarf and a midget.
77. True or false: many species of butterflies, like birds, fly South for the winter.
78. How many hearts does the average earthworm have?
79. Mary drew a picture of a fly with one pair of glasses on. Her brother said,"Mary one pair of glasses won't be enough." Why did her brother say this?
80. True or false: only female mosquitoes bite.
81. Name the animal with the largest brain in proportion to its body.
82. True or false: bees can see ultraviolet light.
83. Where are the cicadas' hearing organs located?
84. What is ichthyosis?
85. Why are the human lips reddish in color?
86. The cheapest pet is probably a______________.
87. Pintos, Mavericks and Mustangs are names of _______________.
88. Why doesn't the water in the ocean freeze?
89. The fastest land animal is the ______________
90. List three animals that weigh over a ton.
91. Who is Mr. Bunsen?
92. What is scoliosis?
93. You're eating a ham sandwich with mayonnaise. Point out the protein, the fat & the CHO.
94. Are brown eyes dominant over blues?
95. Name the bacteria that forms colonies shaped like a bunch of grapes and will

manifest themselves when food is left too long.

96. Name the function of the outer ear.
97. The embryonic human hand begins as a solid stump. What enzyme selectively destroys tissue to form fingers?
98 List ten phenotypes.
99. Name the animal that was sacred in Egypt and also killed Queen Cleopatra.
100. Why is the Dead Sea so named?
101. What is one year in a cat's life equivalent to in human years?

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Nutrition Awareness

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Objective(s):

After the completion of this lesson, the student should be able to:

a) Determine his or her ideal body weight.
b) Determine the kilocalories in fat, protein, and carbohydrate in food.
c) Demonstrate familiarity with the food groups relating to kilocaloric content.
d) Estimate the basic metabolic rate (BMR), energy for voluntary activities and the energy to process food.
e) Identify the food sources of vitamin and minerals and their role in the body's metabolism.

Materials

Charts containing information about:

1. kilocaloric values.
2. vitamines and minerals; their food sources and function in the body.
3. articles on nutrition from newspapers, magazines and publications.

Recommended Strategy

a) To calculate the desirable body weight for an average body frame in females, start with 100 lbs. and add 5 lbs. for each additional inch of height over 5 feet. Males follow the same procedure except start with 110 pounds. Therefore, a female who is 5ft., 4in. tall should weigh within 10 percent of 120 lbs. A male 5 ft., 9 in. tall should weigh within 10 percent of 155 lbs. Individuals with small frames should be close to the lower limit of the +10 percent range, while those with large frames can be near the upper +10 percent range of the calculated desirable body weight.

b) For this part of the exercise the teacher can have kilocalorie charts or have the students figure them out by the following procedure: Determine the grams of the particular food. Multiply the carbohydrate grams times four, the fat grams times nine, and the protein grams times four, and add the products. (Alcohol, not a nutrient, is grams times seven).

c) The kilocaloric chart will also be useful in this part of the exercise.

d) The BMR is influenced by a number of factors: age, height

and sex. The BMR of females is less than that of males and decreases with age; however, it is higher in thin, tall people. To calculate the basic metabolic rate for males, add a zero to the body weight and then add twice the body weight to that number. To calculate the BMR for females attach a zero to their body weight and then add their weight to that number.
To calculate their energy for voluntary activities, the person must classify his/her life style as one of the following:

Sedentary (e.g., office work):add 20 percent to the BMR

Light Activity (e.g., student, laboratory work):add 30 percent to he BMR.

Moderate Activity (e.g., shop worker):add 40 percent to the BMR.

Heavy Activity (e.g., outdoor-type occupation):add 50 percent to the BMR.

e) In order to calculate the energy to process food we need to know the number of kilocalories eaten daily to calculate the number of kilocalories necessary to process the ingested food. The energy required to digest and absorb the nutrients in food is about 6 percent of the daily kilocalories. Students should total the kilocalories from their basic metabolic rate, voluntary activity and food processing requirement and record the information as follows.

Basic metabolic rate.................. kilocalories

Voluntary activity.................... kilocalories
Energy required for

food processing....................... kilocalories

Total energy required daily........... kilocalories

Total energy intake from diet......... kilocalories

Difference between total energy
required and total energy intake
from diet............................. kilocalories

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Observations (collecting data)

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Objectives:

To observe and gather data concerning the earthworm.
To determine the effects of light and incline on the behavior of the earthworm.

Apparatus needed:

Earthworms, live (3 or more)
Dissecting pan
Black paper
Paper towels
Scissors
Light source
Watch, with second hand
Book

Recommend strategy:

1. Place moistened paper towel in dissecting pan.
2. Cover one half of the top of dissecting pan with black paper.
3. Place three earthworms in the pan so that the anterior half of the worms are in the light and the posterior half of the worms are in the dark, under the paper.
4. Shine light on the boundary between the black paper and the uncovered area above the pan for three minutes.
5. Record reaction in table you have made. (Table A)
6. Repeat procedure with earthworms reversed from original positions. (Record in table A)
7. Remove the black paper from the dissecting pan.
8. Place one end of dissecting pan on a book to create an incline.
9. Place three earthworms in the dissecting pan so that the center of the worm is in the middle of the pan with the anterior end toward the raised end of the pan.
10. Wait three minutes and record the number of worms that move toward the raised end of the pan or toward the lower end of the pan. (Record in table B)
11. Repeat procedure with worms in reversed position. (Record in table B)

Analyses:

1. Do the anterior and posterior ends respond equally to light? Explain.
2. Which stimulus seems to be stronger in forcing a response in the earthworms, light or gravity?
3. How is the earthworms response to light and gravity beneficial to the preservation of its species?
4. After a few weeks of drought, the ground may be dug up and no earthworms will be found. After a few days of rain the earthworms are seen on the road and sidewalk surface, even during daylight. Suggest a reason to explain this behavior.

Note: The four previous questions should be discussed and answered after lab. Students should make two tables (A and B) to record the earthworms behavior. Table A should show the earthworms reaction to light. Table B should show the earthworms response to gravity.

Table A Reaction to light after three minutes

Anterior half in light	Movement toward light Movement toward dark	
Anterior half in dark	Movement toward light Movement toward dark	

Table B Response to gravity after three minutes

Anterior end facing upward	Movement downward Movement upward	
Anterior end facing downward	Movement downward Movement upward	

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Diffusion

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Objectives:

1. To develop the concept of diffusion.

2. Demonstrate diffusion of molecules of matter in various states.

Apparatus and materials needed:

Peppermint oil, potassium permanganate, evaporating dish, 250 ml. beaker, glasses, water, powdered drink mix, straws, raisins, pipette, spatula, sandwich bag, marble and teaspoon.

Recommended Strategy:

1. Orally review the structure of the cell by using the sandwich bag filled with water and a marble to represent an analogy of the cell. The students know about the presence of openings in cell membranes and about the possibility of molecules moving through these openings.

2. To demonstrate diffusion, pour sufficient peppermint oil to cover the bottom of an evaporating dish. As each student detects the odor, he or she will raise his hand. Continue until all members of the class have detected the odor of diffusing molecules. At the conclusion of the demonstration, the air and oil molecules have spread out and mixed evenly, they continue to bump and move. This spreading out is called diffusion.

3. To observe diffusion of a solid, fill a 250 mL beaker with distilled water and add several crystals of potassium permanganate. Watch the results as the crystals settle to the bottom. Discuss this phenomenon with the students.

4. To observe diffusion of a liquid, place a glass of water at each student's desk. Do not touch the water; keep the water still for this test. Carefully drop a teaspoonful of powdered drink mix into the glass of water. Watch it for a few minutes without touching the glass. It will go to the bottom and start diffusing.

5. To observe diffusion in raisins, place several raisins in a glass of water. Let them sit overnight. Keep some raisins dry for a control. Distribute to each student some soaked raisins and dry raisins. Let them compare the two kinds of raisins and answer the questions on the worksheet.

Evaluation:

Answer the following questions to show the understanding of diffusion.

1. What is diffusion?
2. Refer to the raisin experiment and explain the difference between the soaked raisins and the dry raisins.
3. What is the evidence that something passed out of the raisins but not everything?
4. What is the difference between the bag's cell membrane and the raisin's cell membrane?.

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Problem Solving: Dots, Symbols, Words, and Proteins

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Objectives:

1. The student will be able to state the steps of the I D E A L PROBLEM SOLVING Method.
2. The student will be able to solve problems using dots, symbols, and word analogies using the I D E A L PROBLEM SOLVING Method.
3. The student will be able to determine the amino acid sequence of a protein given a set of symbolic amino acids.
4. The student will be able to state the amino acid sequence difference between sickle cell hemoglobin and normal hemoglobin.
5. Students will learn that the number and sequence of amino acids identify the protein.

Apparatus Needed:

1. An overhead projector.
2. An overhead transparency of a set of dot puzzles. (Critical Thinking)
3. An overhead transparency of symbolic analogies. (Critical Thinking)
4. An overhead transparency of word analogies. (Critical Thinking)
5. Two sets of transparency forms representing a hypothetical protein.
6. Transparency showing sickled red blood cells along with cartoon sketch of a sick youngster; the same transparency shows normal red blood cells with a cartoon sketch of a healthy youngster.
7. Opaque copy for each student of the sheet for the determination of the amino acid sequence of a hypothetical protein.
8. Opaque copy for each student of the steps of the I D E A L PROBLEM SOLVING Method.
9. Opaque copy for each student of a beta chain segment of normal hemoglobin compared to a beta chain segment of sickle cell hemoglobin.
10. Opaque copy for each student: Questions for Review

Recommended Strategy:

1. Show transparency of item 6 in Apparatus Needed. Solicit responses from students concerning physical effects of sickle cell anemia.
2. Discuss opaque copy shown in item 8 in Apparatus Needed.

3. Show transparency of item 2 in Apparatus Needed. Solicit responses from students concerning steps of the I D E A L PROBLEM SOLVING Method which are:
   I - Identify the problem.
   D - Define the problem.
   E - Explore the possibilities.
   A - Act upon the possibilities.
   L - Look for the desired result.
4. Solve dot problem. Discuss students' strategies used in doing so.
5. Show transparency of Symbol Analogies. Solicit responses from students. Be sure to have each student giving an answer to explain their exploration of possibilities and their action upon them.
6. Show transparency of Science Word Analogies. Allow students to respond to the I D E A L (Identify, Define, Explore, Act, Look) steps.
7. At this point summarize: You have learned that the dot puzzle has parts; if your exploration of possibilities and action on them are sound you will receive the desired geometric figures with the desired dimensions. Symbols have parts with definite spatial arrangement, color, similarities, and differences. If your I D E A L is sound your results are correct. Words have parts (individual alphabets, prefixes, roots, suffixes - all of which give meaning to the word). A change of alphabet within a word may change its meaning or misspell it.
8. This is true of proteins. Proteins are composed of amino acids. Each amino acid has a definite chemical make up; the R-groups identify the amino acid. The number and sequence of amino acids identify the protein.
9. Now we shall follow the method described on your sheets to determine the amino acid sequence in a hypothetical protein. (Item 7 in Apparatus Needed).
10. Show transparency of protein pieces. (Item 5 in Apparatus Needed) Allow students to solve the sequence. Discuss.
11. Change the symbolic amino acid in the sixth position in each of the completed hypothetical proteins. Solicit answers about the result of the change. Is it the same protein? Why is it different? What are some possible results of the change?
12. Refer students to their diagram on opaque sheets of the difference between sickle cell hemoglobin and normal hemoglobin.
13. Show transparency of item 6 in Apparatus Needed again. Discuss.
14. Allow students to answer Questions for Review:
    A. List the steps of the I D E A L PROBLEM SOLVING Method.
    B. How do amino acids differ from each other? State at least two differences.
    C. Compare the Dots, Symbols, and Word Analogy problems with the Protein Composition problem.
    D. State at least two reasons why it is important for the medical

research scientist to know the amino acid sequence in certain proteins.

E. How does Hemoglobin S (sickle cell hemoglobin) differ chemically from Hemoglobin A (normal hemoglobin)?

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Biology/Chemistry

Clouds Movement and Type

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Objective(s):

This lesson is designed for 5th – 7th grade. However, this lesson can be modified for any grade level. Students will learn how to determine cloud movement and direction. Students will be able to differentiate between the different types of clouds. Students will also be able to predict the weather based on the types of clouds they observe.

Materials:

Teacher: mirror, cloud chart, cotton candy, and white paper

Students: construction paper, nephoscope, glue, cotton, scissors, markers and labels

-

Strategy:

You may start with a lead-in motivator such as a cloud in a bottle, a book about clouds or a poem about clouds. You may also tell the children that it is a cloudy day and to just look out of the window for a few moments.

1) Teacher will begin by clouds and what they are.

Questions:

What are clouds?

Where do they come from?

What are they made of?

How do they move?

Are clouds all the same or are they different?

What do clouds remind you of?

2) Describe the different characteristics of clouds.

Teacher will ask students to draw some clouds on the board.

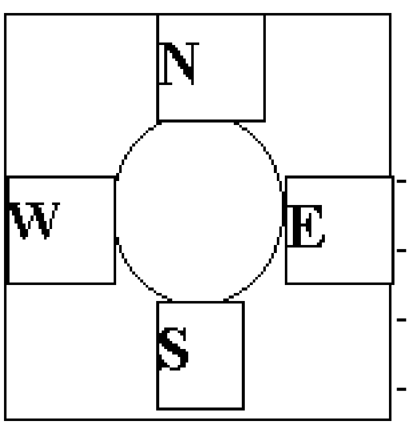
3) Teacher will then ask: Have you ever noticed the cloud movement?

4) Teacher will explain that the direction of cloud movement will tell you the wind direction. It also tells the meteorologists which way the wind is blowing.

5) Students will become meteorologist. Meteorologists use all types of computers and special devices to predict the weather. Well we don't have those gadgets but we can make one. We will make a device call a ***nephoscope.*** This is a device used to help us track cloud movement. We will then know from which direction the wind is blowing.

6) Student will be put in groups of two or three (It depends on how many mirrors you have). Each student will be given a mirror and a handout (the handout should have a square the same size and shape of the mirror with a medium sized hole in the middle. The students should be able to see the clouds moving in the mirror when they lay the mirror on the ground). Students must use scissors to cut out the square and then the circle. The square paper with the hole in it should then be taped on the top of the mirror. The hole should reveal the mirror.

7) Students should now write the cardinal points on the paper (N, S, E, and W). See example below



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8) Teacher and students will now move outside. We are all meteorologists now. We will refer to each other as Meteorologist. (Meteorologist Bobby, etc.)

9) Once outside students first look at the clouds and just observe for a few moments.

10) Next students must place their nephoscopes flat on the ground. They look into the mirrors and notice the movement of the clouds. Students must note what direction the clouds are moving in. (If clouds are moving toward the east then winds are coming from the west). You can use an instant camera to take pictures of the clouds. They will come out perfect.

11) Students will then be told to focus on one cloud. Observe the shape, the movement, and the position of the cloud. Students will then be asked to close their eyes while the teacher counts to five. Students will open their eyes and observe any change in the cloud they focused on.

12) Students will be asked if the cloud is a solid, liquid, or gas.

13) Class will move back into the classroom and take a look at the pictures of clouds. (Chart or photos.)

14) Meteorologists will talk about the different types of clouds and the names for them. We will also talk about the weather conditions that the clouds may bring. We will also discuss the altitudes of the clouds and how it affects cloud movement that brings about the change in weather.

15) Student will be asked if they see certain cloud in the sky what type of weather can they expect.

16) All groups will be given construction paper, glue stick, cotton, a handout, and labels with the names of the different types of clouds. Each group will be asked to create a certain type of cloud and label it, then predict the weather they will expect.

Performance Assessment:

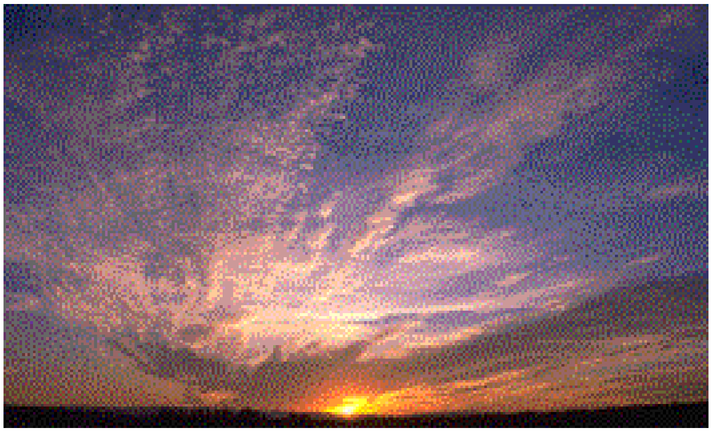
Students will create and label certain types of clouds with cotton, construction paper, and glue. Students will predict the weather based on the clouds they create. Students will name different types of clouds when given a description of the weather. Students should be able to perform successfully at least at 85%.

Conclusions:

The culminating activity will focus on how clouds taste. Students will be asked what do they think clouds taste like. Students will be given cotton candy to eat. They will learn that these types of clouds taste sweet. Students may use the Internet for further observations of weather predictions and clouds.

References:

Science Is…. **Susan B. Bosak. Ontario, Canada: Scholastic Canada LTD., 1991. A source book of fascinating facts, projects, and activities.**



Biology/Chemistry

Natural Cleaners

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Objective(s):

This lesson is designed for 4th and 5th grade students. The purpose of this lesson is for students to gain an understanding of the effects that commercial cleaners have on the environment and teach them to make their own cleaners out of less hazardous materials. The lesson will also meet Illinois State Goal 13:

Having a working knowledge of the relationships among science, technology, and society in historical and contemporary contexts

CAS B

Demonstrate an understanding of the need for protecting, conserving, and efficiently utilizing renewable and nonrenewable natural resources

CFS

Design solutions to selected pollution and environmental problems

Materials:

32 oz bottle of cooking oil, 32 oz bottle of lemon juice, 2 16 oz boxes of baking soda, 2 gallons of vinegar, 1 gallon of distilled water, 7 measuring cups, 7 spray bottles, 25 rags, 1 roll of paper towels, various commercially available cleaners

Strategy:

The students will engage in hands on cooperative learning.

1. The teacher will have a 2-liter bottle of dirty water (waste water from an ordinary kitchen also containing dirt). She will then ask the students if they would drink the water.
2. The teacher will inform the students that there are many chemicals in our water. Many come from industries or from commercially available chemical cleaners.
3. The teacher will tell the students there is a way for us to prevent these chemicals from polluting our water.
4. The teacher will ask the students if they know ways by which we can prevent these chemicals from polluting our water.
5. The teacher will ask the students what chemicals are used to clean their homes.
6. The teacher will ask the students to look at the ingredients of the commercial cleaners that are passed around the class.
7. The teacher will then inform the students that they can clean their homes with natural cleaners.
8. The students will set up an experiment in which they will compare the performance of the natural cleaners to that of the various commercial chemical cleaners.

The following are the recipes for the natural cleaners:

All Purpose Cleaner: Mix 50 ml of baking soda, 125 ml of vinegar, and 4 liters of warm water. Store in spray bottle.

Glass Cleaner: Mix one part vinegar with five parts water. Store in a spray bottle.

Scouring Powder: Sprinkle baking soda on the stained surface and rub with a damp cloth.

Wood Polish: Mix one part lemon juice with two parts cooking oil. Use a soft cloth. Store in spray bottle.

Performance Assessment:

The students will be assessed on their ability to follow directions, document data, and an oral presentation. The total number of points will be 15. The highest score will be five points for each section, e.g. (following directions 5, documentation 5, oral presentation 5).

Conclusions:

As a result of this lesson, one will learn that commercial cleaners contain chemicals which may have effects on the environment and will gain appreciation for natural cleaners as substitutes.

References:

Science Is, Bosak, Susan V. Scholastic Canada LTD 1999

Biology/Chemistry

Rock Formation.

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Objective(s):

The Junior High student will be able to show how rocks are formed by cementation, compaction, and evaporation.

Materials:

EVAPORATION; Each group will need 2 test tubes, 40mL of water, 3-4 teaspoons of salt, 3-4 teaspoons sugar, 2 toothpicks, 2 pieces of string, and 2 plastic caps.

CEMENTATION; Each group will need 2 plastic cups, 1 jar large enough to hold the plastic cup, enough sand to fill the cup ¾ full, enough white glue to fill a cup ½ full, enough water to fill the cup with the glue, and a stick.

COMPACTION: Each group will need a pencil sharpener, 4-5 crayons of different colors, and a 12 inch piece of aluminum foil.

Strategy:

EVAPORATION:

A. Place 20 mL of water into each test tube. In one container add salt until no more will dissolve. In the other test tube add sugar until no more will dissolve.

B. Pour a thin layer of each solution into separate plastic caps.

C. Tie a string to one end of a toothpick and place the other end of the thread into the test tube so it doesn't touch the sides or the bottom of the test tube.

D. Place the test tubes and the plastic caps where they will not be disturbed.

E. Check the solutions daily and record any changes.

CEMENTATION:

A. Poke small holes into the bottom of a plastic cup that will let a solution flow through but not the sand.

B. Fill a cup ¾ full of sand.

C. In a second cup mix ½ cup white glue with ½ cup water.

D. Suspend the cup with the sand over the jar.

E. Slowly pour the glue solution over the sand and allow it to drain through for several days.

F. Cut away the cup when the sand feels dry to the touch and record the results.

COMPACTION:

A. Use a pencil sharpener to make a pile of crayon shavings (use different colors to represent the different minerals) on a sheet of aluminum foil.

B. Fold the edges of the foil to make a rectangular packet.

C. Gently flatten the packet by squeezing it between your palms.

D. Unfold the packet and examine the “rock” that was formed.

E. Return the “rock” to the foil packet and stand on it. Then open and examine it again.

-

Performance Assessment:

The student should be able to answer the following questions.

A. In the evaporation experiment compare what happened to the thin layer solution and the solution in the test tube.

B. In the compaction experiment explain what kind of rock was formed giving at least three reasons.

C. In the compaction experiment explain what happened as more pressure was applied to the packet of crayon shavings.

D. Based on what you know about heat and rock formation what do you think would happen to a packet of crayon pieces that was heated on a hot plate for three or four minutes. Tell what the crayon pieces represent and what kind of rock was formed.

Conclusions:

The student will be able to explain the formation of rocks by the various methods described and infer the formation of other rocks when given information for another type of experiment.

Biology/Chemistry

Land Formations

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-

Objective(s):

This mini-teach is designed for 2nd grade.

The objectives of this mini-teach are:

1. To develop an understanding of how land is naturally developed

2. To learn about several land formations as well as earth science and chemical terminology

3. To provide opportunities for the students to make models of various types of land and to investigate a case of erosion in the formation of a cave

Materials:

Commercial clay of green, blue, and gray colors, play dough, pebbles, sand, teas (for shrubbery), food trays, nine 3x5 cards and newspaper (for keeping the desks clean). A quantity of clay and play dough sufficient for making models of a mountain, lake, bay, gulf, cave, island is needed.

Strategy:

Teacher should introduce the following vocabulary by writing them on the board:

erosion	rain	wind	glaciers	volcano
mudslides	snow	island	gulf	cave

bay lake meadow peninsula mountain

Students will write the terms down and research pictures that illustrate each term.

Pictures of a cave, an island, gulfs, lakes, and mountains will be circulated, discussed and posted.

Students will work in groups of twos to create a model of a land formation. The teacher's model of a cave will be viewed and analyzed. The handout of water going through soil will be distributed to each student. Students will take turns pouring water over the playdough model of the cave to simulate erosion.

Students will listen to the definitions of 3 types of caves: limestone, ice and sea caves. They will also listen to the definitions of a hill and mountain and build models of these as well as caves.

Performance Assessment:

The students are expected to have 95 % accuracy in looking up the words and writing the meanings. Cutting and pasting pictures of the land forms is also acceptable.

The students should show enthusiasm in making the model and successfully completing it.

High interest is evident if students bring in pictures of land formations they have discovered in magazines or newspapers.

Cooperative team effort in making the models is expected from each group. .

Each student will have 3x5 cards to write their names on one side and the types of land formations they see posted on the other side. Learners will place their cards with the name sides showing with the type of each formation underneath not shown. Teacher will collect the cards and mark them.

The above assessment could be repeated until everyone receives 95 % accuracy. Students who achieved 95 % the first time will tutor those who missed naming the land formations correctly.

Conclusions:

Students will understand the differences between pairs of similar landforms such as a hill from a mountain, a meadow from a plain, and a gulf from a bay. They will understand that the actions of water, air, ice, lava and waves pounding on the rocky shores help in creating caves. They will know of the chemical substances in a cave like calcium carbonate, carbon dioxide, and the components of stalactites and stalagmites. The students will learn that chalk is made of (calcium carbonate). We will practice a few chemical formulas such as H_20 (water), $C0_2$ (carbon dioxide), and $CaC0_3$ (calcium carbonate).

References:

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Science Projects & Activities, Peter Rillero, 2000.

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Science & Technology Encyclopedia

Biology/Chemistry

OCEANS…..AWAY

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Objective(s):

This lesson is designed for third and fourth graders. The students will: a) locate on their world map the oceans, seas and continents of the world, b) identify ocean related occupations (marine ichthyologists, oceanographers, underwater archaeologists, and marine ecologists), c) fill in paper models of an ocean floor using the following terms: continental shelf, continental slope, trench, floor and island, d) discuss the Titanic and how an iceberg could be destructive to a ship as well as the Exxon Valdez and the effects it had on the ocean inhabitants then and now, e) unscramble a preplanned food chain, and f) explain, and answer specific questions pertaining to experiments on pollution, salt water versus fresh water, icebergs, and digging underwater.

Materials:

These materials are for groups of four. They are broken down into six stations.

Station 1 -----enlarged map of the world that shows oceans, seas and continents; crayons

Station 2 -----worksheets with ocean related occupations and definitions and pencils

Station 3 -----enlarged paper model of an ocean floor and a list of words and terms that can be cut out and pasted to the ocean floor model; glue, scissors, and crayons.

Station 4------specific pictures of a food chain found in the ocean, crayons, scissors and green string (to represent plant life in the ocean)

Station 5------four different worksheets pertaining to four different experiments and the experiments themselves (see below), pencils

Station 6------research books, articles and/or video clips of the documentaries/movies of the Titanic and the Exxon Valdez disasters, paper, pencils

Strategy:

This activity will take four, forty minute periods.

Day 1

Station 1

Each group of four students will be given an enlarged map of the world in which they will have to label in the continents, oceans and seas. Students will have to do this activity without any aid from the instructor. After fifteen to twenty minutes the instructor will go over the maps using the overhead projector.

Station 2

Discussion of ocean related occupations and their definitions. Instructor will then assign/or have students choose what occupation they would like to hold in their group. The occupations are as follows: marine, oceanographers, ichthyologists, underwater archaeologists, and marine ecologists.

Day 2

Station 3

Instructor will discuss with students about the geology of the oceans and will introduce the following terms: trench, continental shelf, continental slope, floor, and island. The students then will be given an enlarged picture of an ocean floor and using the words and definitions students will fill in the words in the appropriate blanks and color the picture.

Station 4

Instructor and students will engage in a dialogue pertaining to the diets and habitats of fish of the deep. Students will then be given a picture of a food chain drawn out which contain sun, phytoplankton, zooplankton, herring, bluefish and decomposers. Pieces of green string will be attached to the ocean floor (for example, through holes punched into it) to represent the phytoplankton at the bottom of the food chain. Other food chain components will be cut out and also attached to the ocean floor.

If time permits: A sheet will be given to each student group containing various ocean plants and animals and those groups will make their own food chains.

Day 3

Station 5

The instructor will set up at least four experimental stations. The stations should relate in some way to the ocean occupations that the students are exploring. (Suggestions: Surface Tension, Salt water vs. Fresh water and/or Water Pollution). There are many water/ocean experiments available for instructor use on the WEB and in books (examples are listed below).

Station 6

Instructor will either take the students to the local or school library or have available in the classroom reference books for the students use about the Titanic and the Exxon Valdez disasters. Have the students write a short paper on the how these disasters came about and the long range implications each has on today's environment. Students will report their findings to class.

Performance Assessment:

Students groups will be assessed on how well they do the tasks in the lesson.

Conclusions:

Students will gain knowledge and understanding of the oceans and ocean-related occupations.

References:

The Ocean Book. Center for Marine Conservation. John Wiley & Sons, Inc. New York, 1992.

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Angela Patrick - Crown Academy

Somethin' Sweet

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Objectives:

Grades 3-8 (CAUTION: THIS PROJECT REQUIRES MUCH ADULT SUPERVISION)

Students will be able to:

A: Synthesize a delectable delicacy from common chemicals: create candy.
B: Observe how molecules interact with each other in PHYSICAL CHANGES.
C: Observe how the addition of heat can cause molecules to interact and form new molecules in CHEMICAL CHANGES.

Materials Needed:

Per Group:

sugar	water	1 quart pot	whipping cream
measuring cups	stirring spoon	electric burner	candy thermometer
4 jars	large ceramic surface to cool the candy		butter/margarine
	string	4 pencils	

Strategy:

Student background knowledge is needed. These lessons are to be used as part of a unit on matter and molecules. Discuss and do other activities that helps students to understand that matter is made up of molecules.

Molecules are the smallest particles of a substance of matter that will still have the same properties as the original substance. Although a molecule is too small to be seen, chemists can still study how molecules interact with each other. The making of candy will be a fun way to observe the changes in the states of matter: from solids to liquids, liquids to gas, gas back to liquids, liquids back to a solid that is a different substance from that which was started with.

Demonstration: ACTIVITY 1 CARAMEL CHEMISTRY

Place about 1/2 cup sugar into a deep nonstick pot. Place the pan on the burner over low heat. Continuously stir the sugar as you gradually increase the heat. Have the students observe the sugar as it is being heated and describe what is occurring. Eventually, the sugar will melt and break down to form carbon. Keep stirring as you discuss because the sugar melts quickly and could start to stick and burn. Caramel is a combination of sugar and carbon. Remove the pan from the heat when the sugar is straw colored. If you want to make delicious candy caramel, add whipping cream and butter slowly as you stir. Taste the caramel.

The sugar has been converted to caramel through a chemical reaction. If heated too long, the sugar turns the dark brown color of carbon and loses all of its sweetness - an interesting change, but not tasty. The heat causes the sugar molecules to chemically change into a different substance, therefore it looks and tastes differently from the original white sugar.

Student Group: ACTIVITY 2 ROCK CANDY AND MOVIE GLASS

Put 1 cup of water into a pot on the burner. Slowly add in 2 cups of sugar. Constantly stir over the heat until the sugar dissolves into the water. Slowly add up to another 2 cups of sugar (or as much sugar that will be dissolved into the water over the heat). Remove the sugar from the heat before the solution reaches the boiling point. Use the candy thermometer to make sure you have reached the temperature of 270 degrees.

MOVIE GLASS:

Pour the hot mixture onto the flat ceramic surface to cool. In about an hour, the mixture will start to cool and harden. This is the solution that hollywood movie-makers use to create the "glass" bottles and windows that the actors are hit with or thrown through. The solid sugar molecules (crystals) dissolved into the water to become a liquid. As the liquid cools down, the crystal molecules return to a solid that appears translucent.

ROCK CANDY:

Follow the directions above to heat the sugar. Take the string and tie a paperclip to one end. Tie the other end around a pencil. Put the string into the jar and have it hanging towards the center from the pencil that is placed over the jar's opening. Pour in the hot sugar solution. Sit the jar in a cool and dark place for at least 2 days. The students should begin to see the sugar begin to return back to the solid crystal form. This time the sugar crystals will be larger than before but will be in the same form. This is a Physical Change.

Performance Assessment:

Each child will be able to write a description of what is occurring to the sugar. In this description, they must be able to state that the activity that involves dissolving the sugar into the water is a physical change that occurred when the sugar molecules became a liquid. The liquid then turned into a gas as it boiled. When the solution was poured into an item to cool, it returned to a solid.

Each child must also describe the difference between the chemical change with the sugar over the heat, and the physical changes when dissolved into the water.

Conclusions:

The molecules of a substance of matter can be changed in two distinct ways. One is a physical change where the molecules can be returned back to the original form. The second is a chemical change where the molecules react to form an entirely different substance.

References:

Book: 365 Science Projects
Internet: SOAR (Searchable Online Archival Recipes)

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Joyce E. Combest - Daniel Dale Williams School

Can Young Children Distinguish Between Living and Non-living Things?

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Objective(s):

This science project has been designed for Head Start children (ages 3 and 4 years old) so that they will be able to identify living and non-living things as a result of their learning through discovery from their observation of and interaction with a set of natural phenomena in their community. Each teaching/learning session lasts from 10-15 minutes which consists of large groups (of 15-17 pupils) or small groups (of 3-6 pupils) who work in teacher directed activities or child selected centers.

This science module is to be implemented through the integrated unit approach while simultaneously relying heavily on a set of guide-lines referred to (in the field of Early Childhood Education) as "Developmentally Appropriate" practice. The concept provides a frame-work for program planning that embraces age and individual appropriateness in all four (physical, emotional, social, and cognitive) domains. The forthcoming strategy is to be implemented with attention to different needs, interests, and developmental levels, via behavior modification-techniques so that each child may realize a measure of success.

In terms of subject matter, what will be the focus of study? For organic or living things, it will be various materials from plants. For inorganic or non-living things, it will involve observing and collecting objects such as rocks, gravel, pebbles, sand, concrete, and bricks; other non-living subject matter will include items made of steel, brass, silver, copper, aluminum, plastic, glass, and clay, such as nails, screws, coins, cups, glasses, etc.

Materials Needed:

- -Two tables for displaying materials
- -Two sheets of poster board for labeling centers
- -Two 8"x11" comb binders
- -Two Polaroid cameras
- -Assorted construction paper, plastic plates, and tempera paints for art
- -Brown paper lunch bags (approx. 7"x4")
- -Glad cling wrap and miniature rubber bands
- -An assortment of 10 fruits, vegetables, nuts and legumes, (organic or living items)
- -An assortment of 10 small safe household inorganic or non-living items as described above
- -One-half dozen oranges
- -Childrens' safety scissors
- -Stick glue

-Black yarn
-Multi-color felt tip markers
-Magazines (for cutting and tearing)
-A rock and soil collection
-A rock, mineral and crystal study set
-A rock and soil sample set
-Science picture concept cards
-1 globe

Strategy:

It is proposed that the following activities will enhance children's understanding of the difference between living and non-living things.

(1) Nature walk: Divide class into groups "A" and "B" and go on a nature walk. Group "A" will take pictures of Living Things; group "B" will take pictures of non-living things. Later, arrange and place photos in a booklet for additional observation and study. Alternate groups may recite related songs and poems outside such as "We Need Trees", "I am Looking for a Rock", and "Boulders and Stones".

(2) "Feel and Find" Game: Place four items in each brown bag. In so doing, select two different items from each category of "organic" and "inorganic" objects; then choose ten pupils to play the game. Each student is asked to take something out of the bag and name the item orally. Children are given turns to answer in sequential order. All children have items that have been carefully prepared and placed in plastic wrap for health purposes.

(3) Half Orange Art: Place a small amount of tempera paint in each of eight plastic plates; use red, yellow, blue, brown, white, orange, purple, black, green, pink. Take an orange cut in half across the sections. Give each child a half. Pupils will dip the orange in paints and create artistic designs. Children learn that an orange is considered a living object, but the paints are not.

(4) "My Own Book": (A) Children will browse through magazines, select pictures of living things, cut them out and use stick glue to arrange them on white 8"x10" construction paper. Punch three holes (in notebook fashion) in each picture page and tie with black yarn. Each child draws a picture of himself on the front cover of his booklet. (B) This activity can be repeated using non-living items.

Teacher provides support and encouragement for the act of taking responsibility for the completion of assigned tasks; for showing empathy and concern; and, for responding to the needs of others. Teacher approval is administered via immediate positive reinforcement for each successful approximation of the desired behavior until it is shaped.

Performance Assessment:

Students should show that they have achieved the desired outcome behavior (and the instructional objective) by distinguishing between the two concepts above (living and non-living things) with 80% accuracy, by naming, selecting, classifying, arranging, and matching in oral and written form.

The teacher will utilize a "six item" criterion referenced test or rubric (based strictly on the conditions of the behavioral objective) to ascertain if the student can differentiate between living and non-living things. The set of "six competencies" will be accompanied by six boxes to check that will indicate mastery of the concept.

References:

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New York: Troll Company

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Elaine Pauline Agusto-Laster - Daniel Hale Williams Elementary School

Stacking the Deck on Nutrition

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Objective(s):

To introduce and demonstrate the word classify. This will be done by having students arrange a variety of foods into their proper food groups. This and other related activities will aid in the development of the students' critical thinking skills.

An introduction to the food pyramid and the grouping of food will provide for students an awareness of how foods are categorized, as well as their levels of importance to the human body.

Materials Needed:

Construction paper; Food Playing Cards; 3-inch by 5-inch index cards; paste or glue sticks; scissors; crayons or markers; *The Pressure's On!* scorecards; and pencils.

Strategy:

Discuss with the class that classifying is a way of assigning (a thing) to a class or category. Demonstrate on the chalkboard how classifying is done. Have a food ready list for students to select from. From this list, have students place each of the foods into their correct sections.

Through a variety of class activities students will learn how foods are classified, and are arranged into groups on the food pyramid. In the first activity the class will play the game *Go Fish!* (1) Divide the class into groups of three and give each group a set of cards. (2) Deal seven cards face down to each player and put the remaining cards face down to form a draw pile. (3) If players have two foods from the same food group, they place them down as a match. (4) In turn, each player asks the player to the left for all the foods from a certain food group. For example, Horace might say to Hilary, "Give me all your Grains." If Hilary has cards from the Grain Group she must give all of them to Horace. If not, Hilary says, " Go Fish." Horace then has to draw from a pile. (5) Play continues until a player has matched all of the cards and has none left in his/her hand. That person is then declared the winner.

The second activity is called *The Pressure's On!* The concept, of this activity, is that foods vary in amount of sodium, cholesterol, and fat that they contain. Limiting the amount of these substances in the diet can help reduce the risk of heart disease. The objective is for the player to have the least amount of sodium, cholesterol, or fat when the foods cards are totaled. The directions for this activity are: (1) Prior to class, photocopy one set of Food Cards for each group of six. Then photocopy one *The Pressure's On!* Scorecard for each person. (2) Divide the class into groups of six and give each group a set of Food Cards, which have been cut apart and shuffled. Turn the cards face down on the desk or playing surface. (3) One at a time, in turn, each player draws a card, turns it face up, and announces the food, and the amount of sodium. That person then records the amount of sodium on their score card under the sodium column. Continue choosing, and recording until all forty-eight cards have been selected. (4) Each player adds up the total amount of sodium on their cards, and the player with the fewest milligrams is the winner. (5) Shuffle the cards, and play again, but for this round, count total milligrams of cholesterol. Once again, the lowest amount wins. (6) Shuffle and play round three counting grams of fat. Again, the lowest amount of fat is the winner. (7) Discuss the effects large amounts of sodium, cholesterol, and fat have on health.

Performance Assessment:

To assess the students' understanding of classifying, give each student a pre-drawn food pyramid on construction paper and reproduce sheets of the six food groups. Tell the students that they are to place each of the foods in their correct food groups.

Conclusions:

The students have gained a greater understanding of classifying. They also have an awareness of the food groups, and what foods have a significant or insignificant value to the human body. Most of the activities were hands-on and allowed for greater student participation.

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Toner, Patricia Rizzo. **Diet and Nutrition Activities.** New York: The Center For Applied Research in Education, 1993.

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Imara Abdullah - Douglas Community Academy

Calorie Connection

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Objective(s):

Measurements require using standardized units. After studying measurements in customary and metric units the students will be exposed to using heat as a measurement unit in determining the calories of a brazil nut. Next the burning of sugar occurs so fast it can be compared to the quick energy rush that occurs when sugar is burned in body. Finally, the charts with caloric measure of different food will show the work scientist have done in computing calories. The computation of the number of calories needed while at rest and with daily activity level will connect the caloric measure to the body metabolism.

Middle grade students will understand the term calorie.
Middle grade students will understand that sugar burns quickly in the body.
Middle grade students will compute the calories needed for his or her body according to their usual activities.

Materials Needed:

Ring stand, foil pie pan, thermometer, long matches, paper clips, shelled Brazil nut and clay.

Ring stand, foil pie pan, matches, calorie charts with a variety of foods on it.

Formula for computing basal metabolic rate
Formula for computing calories for body weight and activity level
Chart of average body weights and average caloric intake needed for boys and girls
Scale to weight students

Strategy:

The strategy is phenomenological, using strategies in which students can observe, interact, collect data, and discuss concepts through answering questions from observed activities.
Brainstorming is used and students are asked to draw conclusions about observations. Students are encouraged to form an hypothesis and follow the scientific method in testing and re-testing their hypothesis.

PROCEDURE:

Calorie Experiment:
Set up ring stand and foil pie pan with 100 milliliters of water in the pie

pan. Record the water temperature. Put a Brazil nut on an opened paper clip Place the bottom of the paper clip in the clay. Place the Brazil nut and the paper clip directly under the pie pan. Stabilize the position of the nut on the paper clip by putting the end of the paper clip in clay and pressing the clay down. Light the Brazil nut with the matches. Let the nut completely burn up under the foil pie pan. Now measure the water temperature in the pie pan with the thermometer. Note the differences in the water temperature. Each degree of rise in temperature was caused by the release of one tenth kilocalorie from the nut. Multiply difference by 1/10th because 100 milliliters was used (1/10th of a liter). Take beginning temperature of water subtract that temperature from the ending temperature of water. Multiply difference by 1/10th for calories of a Brazil nut.

Sugar Experiment:
Set up ring stand and foil pie pan. Place small amount of white sugar in pie pan. Light matches and place under pie pan. Heat pie pan until sugar melts.

Caloric Intake activity:
Use scale to weight students. Use calorie charts of average caloric intake for boys and girls and charts of calories needed for average activities. Examine charts with students. Calculate calories needed for daily intake. The basal metabolic rate, for women, is determined by taking your weight and multiplying it by 10. Then divide that number by the number of minutes in day. For men the basal metabolic rate is determined by taking your weight and multiplying it by 11. Next divide the number by the number of minutes in a day. Note the average person burns approximately one calorie per minute. Next use charts to compute number of calories needed per day for specific ages and activity levels.

Performance Assessment:

Create rubric of performance task and participation requirements.

Conclusions:

A calorie is the unit standardized to measure food energy. A kilocalorie is the amount of heat energy that is needed to raise the temperature of one liter of water by one degree celsius. Sugar is used as quick energy by the body. But the body needs energy to perform task and food to provide balanced nutrition. Scientist have computed the caloric value of many foods. Charts are available of calorie amounts.

References:

Heath Science, D.E. Heath and Company, Lexington, Massachusetts
Copyright 1984, Book 5

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Biological Flight

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Objectives:

This lesson is for K-6th grades. Students will learn about the many different ways that seeds fly in birds, in air, and why. They will collect seeds, learn Bernoulli's principle including lift, ailerons, elevators, drag and how to make a paper helicopter that simulates some seed flights. It integrates botany, biology, zoology (how birds are built to fly), chemistry, physics, and art with student drawings, tracings and a picture of Brancusi's sculpture entitled "Bird in Flight."

Materials Needed:

Paper, pencil, scissors or paper cutter, scotch or plastic tape, (all of the following are optional items you may wish to use and/or give to your students) including carbon paper, stapler and staples, a photocopy of the encyclopedia article regarding Bernoulli's principle, and a photocopy of the Brancusi's sculpture cited above from any good encyclopedia.

Strategy:

1. Take the children outside to collect seeds and sometimes things that look like leaves. Or have them bring to class different types of seeds they find. Throw the seeds up into the air or drop them from as high as you can reach, to illustrate how they fly. Explain that on a windy day many will fly farther. Note: if you stand on a chair, your students will quickly imitate you,
2. Cut a strip of paper, 2" by 8" and hold it to the tip of your chin with your index finger. With your lips slightly pursed, blow air above the paper in a thin fast stream. The paper should rise, because, according to Bernoulli's principle, air or liquid moving faster than the things around it creates low pressure in the flowing area. Therefore, the air underneath it has a higher pressure and pushes up creating "lift". However, if you put the edge of the paper beneath your nose, and blow a thin stream of air beneath the paper it will also rise, but, this is due to the force and speed of the air flow. It is not caused by Bernoulli"s principle.
3. Explain that the outer coatings of some seeds must be dissolved by the digestive juices of certain birds before they can germinate. Therefore their flight only ends when they are excreted, either by the bird in flight or resting on a branch or after a baby bird in the nest excretes the seed. Can you think of other animals that might carry seeds this way?
4. Dandelion seeds fly through the air by wind but burr type seeds fly by sticking to the coat of animals or onto clothing of anyone, like velcro.
5. Maple tree seeds and other seeds fly like a helicopter and although they are normally encased in a single wing, it twirls like a helicopter rotor which is the large main blade that keeps it in the air. **To make a paper helicopter**, take an average sheet of paper (8 1/2" by 11"), and fold it lengthwise in half. If your class does not have scissors easily available

to them, just have them fold and re-fold the paper back and forth several times. Explain that this folding weakens the fibers in the paper so that it will tear much more easily and accurately.

Tear it in half. If the paper is lined, fold it in half again and tear it from the top down 13 lines, including the one inch large space at the top of the line. If the paper is unlined (plain), fold it lengthwise from the top only one-half way down to the middle of the paper. Re-fold it several times and along this vertical line tear it down only to the middle of the paper. See the diagram below. Bend the wings about 30 degrees in opposite directions.

```
 ________________    _________________    ________________
| one half of    |  |        .        |  |                |
|    your        |  |        .        |  |                |
|    original    |  |        .        |  |                |
|    sheet       |  |        .        |  |                |
|     of         |  |        .        |  |                |
|    paper       |  |        .        |  |                |
|                |  |    fold         |  |                |
|                |  |    and          |  |.....      .....|
|                |  |    tear to      |  |   last         |
|                |  | make the rotor  |  |   fold         |
|                |  |   wings         |  |   and tear     |
|________________|  |_________________|  |________________|

              ________________
             |       |        |
             |       |        |
             |       |        |
             |       |        |
             |       |        |
             |.......|........|    Your finished product
             |                |
             |_____      _____|
                  .     .
                  .     .  Dotted lines are where folds must be.
                  ._____.
```

Then skip about 1 and 1/2" and make sure you do nothing to this sort of middle section of this paper. Gently fold the bottom of the paper up along this imaginary horizontal line that is 1 and 1/2" below the bottom end of your vertical tear.

This is the hard part. You must be very careful not to tear it too far in on either side. We will now explain. On this horizontal line, tear in from each edge only 1/3 of the way toward the center and stop. Now, fold in these two sides so that each one exactly covers the middle side. You now have something that sort of looks like a "Y". Hold it up as high as you can reach, and in one motion, pull it down and let go at the same time, to make it fly.

Performance Assessment:

Oral questioning and discussion for the examples. Observation and/or grades for the completion of the hands-on paper helicopter project.

Conclusions:

This is a successful introductory lesson to a unit on seeds and parts of a plant. Children will be bringing in examples of flying seeds long after this lesson is over.

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A Taste of Our Classroom

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Objectives:

This lesson is geared toward 3rd thru 6th grades. Students will learn:

1) To list the four tastes that the tongue can detect.
2) To map the individual areas of taste on the tongue.
3) To demonstrate the ability to identify objects through the use of taste.

Materials Needed:

blank paper
drawing paper
crayons
construction paper
tape
glue
scissors
pencils
students in groups five or six
food items for each of the regions of the tongue:

1) sweet (example: cookies or candy)
2) sour (example: pickles or lemons)
3) bitter (example: tonic water)
4) salty (example: pretzels or salted peanuts)

Strategy:

Activity A (Who am I Game?)

Twenty five slips of paper will be in a paper bag. Each student will select one slip of paper. Each individual slip of paper will have a description of a different food item on it. Every student will take a turn reading the description of their food item orally to the class. After the student has read their description orally, the rest of the class will try to identify the food item.

Activity B (Brain Storming)

All students will be divided equally into four groups. There will be a group for each one of the four taste areas (sweet, sour, bitter and salty). Each group will be required to list as many foods as they can for their category. After each group completes their food list, they will draw a picture of a tongue, and label each region. Afterward the students will color and identify the region of the tongue that their list represents.

Activity C (A Taste of Classroom)

Every student will select a food item from the "Taste" buffet. The "Taste buffet will contain items that are sweet, sour, bitter and salty. Afterward, the students will identify on their tongue map what category the food item came from. Also, have the students list the food ingredient which made the food taste sweet, sour, bitter or salty.

Activity D (Making the Tongue Map)

Students will make a model of the tongue and identify each region.

Performance Assessment:

Students that complete activities B thru D will receive a letter grade of A.

Conclusion:

At the conclusion of this mini-teach, the students will be able to identify the four major taste buds: bitter, salty, sour and sweet.

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Usefulness of Irrigation

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Objective:

To show that water is necessary for plant growth.
To show how a dam can turn a nearly useless water way into a valuable form of irrigation.

Materials:

Lima beans
Dry soil
Paper cups

Lima beans
Soil
Paper cups
Water

Dam
2 plastic straws
pail
2 catch pans
2 flexible tubes

Plywood 36 x 30

Procedure:

Attempt to grow the lima beans in very dry soil. After 7 days, plant some more lima beans in very rich soil and water regularly. Compare the beans in size and growth development. Keep a growth chart.

To construct the dam, cut pieces of 1/4 inch plywood according to following dimensions; front piece 36 inches long, 6 inches high, 6 inches wide, cut 2 angles 9 inches from each end and 2 inches above the base. To construct the back piece, cut 36 inches long, 12 inches high, 12 inches wide, 2 angles 8 inches from each end and 8 inches above base. Cut 2 side pieces, 30 inches long, 12 inches high slanting from 12 inches to 6 inches. Cut 4 top pieces, 33 inches long and 10 inches wide. Nail the front, back and sides together. Caulk joints. Cut triangle piece for dam. Drill 2 holes in the triangular piece same size as straws. With a straight pin, punch holes along one side of each of the two straws. Plug one end of each straw. Push the other end through the dam. Set a pail of water on a platform behind the model. Put the 2 flexible tubes in the pail and let water run slowly into the troughs. Water will flow right out of the trough without a dam. A lake will form behind the dam and the irrigation pipes will take water to dry areas for watering of the soil.

Conclusion:

Plants must have water in order to grow. Through irrigation pipes, water can be directed to dry areas where it is needed as long as there is a source of water such as a dam.

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Water Conditions

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Objective:

The main objective of this Mini-teach is to show students that water is an important physical factor (abiotic) in the environment of all living things.

Materials Needed:

- petri dish
- stapler/staples
- paper towel/filter paper
- vinegar-soaked radish seeds
- alcohol-soaked radish seeds
- forceps
- tooth picks
- water-soaked radish seeds
- soap-soaked radish seeds

Strategy:

1. Divide your petri dish into four parts. Use the filter paper/paper towel, tooth picks and stapler.
2. Label the four parts as follows; Water, Vinegar, Soap, Alcohol (in pencil).
3. Wet the paper towel/filter paper in the petri dish.
4. Place five water-soaked radish seeds on the part of the dish marked "Water".
5. Use your forceps, rinse off five vinegar-soaked seeds. Place them in the part of the dish marked "Vinegar".
6. Use your forceps, rinse off five soap-soaked seeds. Place them in the part of the dish marked "Soap".
7. Use your forceps, rinse off five alcohol-soaked seeds. Place them in the part of the dish marked "Alcohol".
8. Cover the seeds with a wet paper towel circle or filter paper.
9. Label your petri dish (name & date). Store your experiment for a few days.
10. After a few days, examine your seeds.

Performance Assessment:

At the conclusion of the Mini-teach, students will be able to answer the following questions:

1. What were the four environments of your seeds?
2. Which seeds do you predict will not grow?
3. Which seeds do you predict will grow? Explain your answer.
4. What happened to the vinegar-soaked seeds?
5. What happened to the soap-soaked seeds?
6. What happened to the alcohol-soaked seeds?
7. What happened to the water-soaked seeds?
8. Suppose you had placed five dry seeds in a dry petri dish, what would have happened and why?
9. What must the environment provide seeds before they can grow?
10. What must all living things obtain from their environment?

Conclusion:

Students will understand that water is an important physical factor in the environment of all living things.

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Measuring Matter

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Objective:

The fourth grade students will measure the mass of objects using a balance scale and measure the volume of an irregularly shaped object, using displacement.

Materials needed:

balancing scale
coins
paper clips
pencils
blocks
rocks
soda can
water
crayons
heavy thread
50-ml graduated cylinder
bolt
books
nails

Recommended Strategy:

Phenomenological approach and Performance assessment

1. Review the following terms:
   matter, solid, liquid, gas, mass, grams, centimeter, and milliliter
2. Place an apple in a sack and staple the sack shut. Leave another sack flat and staple the top of the sack shut. Pass both sacks around for the students to observe and determine which sack contains a solid, liquid or gas object. Have the students name the object in the sack and describe to the class the shape, color, size, and weight of the object.

Performance Assessment:

Part I

A. Place a coin in one of the balance pans.
   1. What happens to the balance?
B. Add paper clips to the other balance pan, one at a time, until the pans balance.
   1. How many paper clips are needed to balance the pans?
   2. What is the mass of the coin?
C. Find the mass of other objects.
   1. What do you predict the mass of each object will be?
   2. What is the mass of each object?
   3. How can the balance measure mass?

Part II

D. Set a graduated cylinder on a table, away from the edge. Fill it with water up to the 20-ml mark.

   1. What is the volume of the water in the graduated cylinder?
E. Tie a piece of heavy thread around the bolt. Make sure the thread is long enough for you to hold onto when the bolt is lowered into the graduated cylinder.
   1. What do you think will happen to the water when you lower the bolt into the graduated cylinder?
F. Carefully lower the bolt into the water. Watch the level of the water.
   1. Describe what happened to the level of the water.
   2. What is the volume of the water in the graduated cylinder now?
   3. How much did the bolt increase the volume of the water?
   4. What is the volume of the bolt?
   5. How is a graduated cylinder used to measure the volume of an object? The volume of the displaced water is equal to the volume of the object.
   6. Use your graduated cylinder to find the volume of a crayon.

Multicultural Statement:

The metric system is used universally. Children of all cultures can benefit from the understanding and use of the metric system.

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Dinosaur Tracks and Critical Thinking

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Objectives:

This activity is designed for classes from 5th grade up.
Students will learn the major geologic eras.
They will learn the rudiments of how tracks are made and how to read them.
They will use powers of observation and critical thinking to produce a scenario.

Materials Needed:

This activity can be designed as an individual project or class project.

As an individual project, small boxes like shoe boxes can be used. These will have the bottom part of the box covered in clay.

As a class project, you will need a 1/2 inch thick piece of plywood about 3 feet square, 4 2x4s about 3 feet in length, and a 25 lb. bag of plaster. The four 2x4s will be used as a border for the plywood. Pour in plaster and water, mix well and begin to form a landscape.

Strategy:

You will want to create a landscape. I suggest a plain with a river running through it. This can be formed by hand or a stick. You will have to work quickly as the plaster sets within an hour. Once the landscape is formed you will begin to place the tracks in the wet plaster. I recommend using a pencil as a stylus. The form of the tracks will be chicken-like for the carnivore and circular for the herbivore. Have a story-line in mind before you begin placing the tracks. Once finished, allow the plaster to dry and then use spray paint to create the impression of grass and water. The story-line should be as involved as possible, providing a lot of evidence for a wide variety of interpretations.

Performance Assessment:

The students will be asked to observe the model carefully all the while taking notes and bearing in mind that the sides of the model represent the cardinal points. Then they will return to their seats and will be asked to write a scenario for what they have seen based on the evidence they have found. Though the instructor will have had a story-line in mind when the model was made, it is important to remember that there are **no right answers**. Any scenario described is correct if accompanied by sufficient evidence to support the view. Students should be counseled to give complete descriptions. Try to include evidence that will allow the students to completely describe the scene, e.g. weather, direction of wind, time of day, etc. and include these factors in their discussion of the scenario.

Students will be assessed on the basis of accounting for each set of tracks with a full discussion of the type of animal that made them and what information can be inferred from the tracks. They will need to delineate the sequence of events from the start of the scenario to the end.

Evaluation:

This activity is directed to exercising and sharpening students' critical thinking skills. It also incorporates a writing component making this a multi-disciplinary activity. For students from multi-cultural backgrounds whose dominant language is other than English the activity itself represents no obstacle since very little discussion is needed to get the students started However the assessment portion of the activity could be modified to allow the student to write in his native language or draw a diagram using a basic vocabulary and numbering system to demonstrate comprehension.

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Discover Science

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Objective:

To determine if students have mastered the following skills:

1. Comparison
2. Observation
3. Identification
4. Data Gathering

Materials:

1. Various mounted photos from magazines of plants, animals, insects and fish that relate to the questions provided by teacher.
2. Lab equipment such as:
   a) beaker
   b) graduated cylinder
   c) slide
   d) cover slip
   e) microscope
   f) thermometer
   g) hand lens
3. Graph paper
4. M & M's
5. Timer

Strategy:

Collect an assortment of photos from wildlife and science magazines. Mount the photographs on construction paper. Display the photographs around the classroom. Place a question pertaining to the photos beneath each of the pictures. Questions related to science experiences and students prior knowledge will also be displayed on walls and bulletin boards in the classroom. Provide an answer sheet that is numbered to correspond with visual displays and questions. Students will be allowed to observe photographs and questions for 2 minutes (teacher will use a timer) at each station. Students will be encouraged to move on after 2 minutes in order to allow everyone an opportunity to view and read each question and visual display. (Please note that no talking should be allowed.) Provide questions that may touch on the vocabulary as follows:

1. Knowledge - recalling previously learned information

2. Comprehension - understanding/translating

3. Application - applying knowledge

4. Analysis - relating elements of what's observed

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5.  Evaluation - making judgements on definite criteria
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Data Sampling

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Objectives:

Students will be introduced to data sampling.
Students will turn the data collected into useful information, make graphs and use the graphs to solve problems.

Materials needed:

600 mL of soil for each group
uncooked twist macaroni (worms)
dried lima beans (seeds)
small rocks
large sealable plastic bags
measuring cups
newspaper
rulers
balance scales

Strategy:

Divide the class into four groups. Give each group, except one, a soil mixture of 600 mL of soil, 15 lima beans, 150 mL of rocks and 75 mL twist macaroni. The other group will get the same soil mixture, except use 150 mL twist macaroni instead of 75 mL macaroni. Label each bag with a different letter corresponding to a different spot on a backyard map you have drawn on the board or overhead projector. Do not tell which group has the bag with the most worms.

Tell the class this story;

You love to fish and decide that you would like to take a few friends on a fishing trip on Saturday. You will need a lot of worms (at least 50). You will need to dig many holes in the backyard to find that many worms. Your mother would rather you not dig so many holes in her yard. You remember in science class that you learned about sampling. You ask if you can dig just four holes and from these four holes you will examine the dirt and replace the soil. By taking these four samples you can pick the best spot for worms. Then you will need one large hole in that spot and you promise to fill it in again. Your mother loves the idea and, thanks to science, your fishing trip is saved.

Pass out newspaper, bags of soil, measuring cups and maps of the backyard. Have balance scales and rulers on a nearby table so the students can use these as part of the observations. Share these predictions with the class by writing the results of the findings on the chalkboard. Predict at this time which soil mixture will have the most worms.

The students will complete a table and organize their data. Pass out a data table with columns marked "number of worms", "number of rocks" and "number of seeds." Label the rows of the table with the soil amount (75, 150, 300, 450 and 600 mL). Count only the contents of the 75, 300 and 600 mL sample and predict the contents of the remaining two. Each child must replace each soil sample completely into the bag before taking the next measurement. At no time should the entire contents of the bag be dumped onto the newspaper. Only the measured amount needs to be poured out for counting.

Conclusion:

Using the measured data, have students complete the table and predict the missing data. Discuss these predictions and record them on the chalkboard or the overhead projector. Draw three graphs using the soil measurements (x-axis), and the observed number of seeds, worms and rocks (y-axis). One student from each group will graph his groups counting for each graph. Compare the graphs with the tables. The class can decide which soil mixture is worm rich by using the graphs and the tables.

Evaluation:

Post activity discussion can focus on some of these questions:

1) Which method of prediction was easier, using the tables or graphs?
2) Can you name four ways in which we observed the soil?
3) Can you name other ways in which data collection can be used in real life?

References:

Reeling in Data Samples, Janis Lange and Stephanie Williamson
March 1990 Science and Children

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Physical And Chemical Change Of Six White Substances

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Objectives:

(1). To determine whether the reaction between selected white substances and vinegar, water and iodine are chemical or physical.
(2). Make a hypothesis using observation, touch and smell.
(3). Through chemical analysis the students will be able to determine what happens to each of the substances - i.e. will they (a) clump or clot; (b) bubble or fizz; (c) separate; (d) give off a sweet or foul odor; (e) change colors.

Apparatus Needed:

(1). Petri dishes or Egg cart.
(2). Six white substances: powdered sugar, salt, baby powder, cornstarch, baking soda and plaster.
(3). Water
(4). Vinegar
(5). Iodine

CAUTIONS TO STUDENTS:

Use of iodine can cause damage to clothing, irritation to skin and breathing iodine can be hazardous to your health.

Strategy:

Test each substance individually with the following materials: water, vinegar and iodine. Make a hypothesis using observation, touch and smell.

Conclusion:

The substances have been identified as follows: powder sugar, salt, baby powder, cornstarch, baking soda and plaster.

Vocabulary:

Physical Change- is one in which the appearance of matter changes but its properties and makeup remain the same.

Chemical Change- is a change that produces one or more kinds of matter that are different from those present before the change.

Chemical Property- the ability of substances to undergo or resist chemical change.

Observation- is an examination of something in nature. Observing is more than seeing, it requires attention to details. It is a skill that requires patience and practice.

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How Big Is Big?

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Objectives:

This activity, as described, can be used effectively, in grades 2 thru 6.
This project should be used as a culminating activity, after the completion of the unit on whales.
To reinforce the enormous size of the whale.
In this activity, students will assemble a life-size whale, outside of the school, using a picture of a Humpback whale on a grid.

Equipment and Materials:

Humpback whale puzzle
Humpback whale grid
Whale-size comparison chart
Crayons and markers
Yardstick
Transparent Tape
8-9ft. X 12ft. (108 sq. ft.) heavy weight plastic drop-cloths

Preparation:

You will need a copy of the Humpback whale puzzle and Humpback whale grid for each student. You will need a space at least 48 ft. X 18 ft. for the full-size drawing. An outdoor area is best.

Procedure:

Introduce the project to your students by reviewing the body parts of the whale, the Humpback whale puzzle and the Humpback whale grid, previously completed in prior lessons. Refer to Marine Life: Whales and Anatomy of a Humpback in this book.

Recommended Strategies:

Tape together eight drop-cloths to form a rectangle measuring 18 ft. wide by 48 ft. long.
Mark off and draw squares totaling l0 squares in length and 5 squares in width.
Assign one square of the Humpback whale puzzle picture to each student.
Have the students find the box on the large grid that matches the letter/number coordinate key of their piece.
Instruct the students to reproduce their small part of the whale into the appropriate box.
It will be important for you to monitor the boxes that form the outline of the whale. Lines that start in one box and extend to the next must meet.
For maximum effect, place your entire class **inside** the whale!

References:

Museums:
John G. Shedd Aquarium
Field Museum of Natural History

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Extra Sensory Perception

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Objectives

1) Class will cooperatively define E.S.P.
2) Class will cooperatively identify the relationship of E.S.P. to man's five senses.
3) Class will classify experiences of examples into respective categories.

Equipment and Materials

Oak tag strips with ESP terminology.
Chalkboard and chalk.
Overhead projector and diagram of mind.
Excerpts from listed bibliography mounted on construction paper.
Pro and Con packet for further discussion.

Bibliography

Science Good, Bad And Bogus Martin Gardner
Mysteries of the Unknown Time Life
ESP Christopher Milbourne

Recommended Strategies

Review five senses and their respective functions. Develop concept of extrasensory perception. Elicit from students some characteristics which determine some ESP phenomena. Exhibit illustrations and distribute to students some excerpts from **Mysteries of the Unknown**. Have student place each excerpt under respective category.

Assign debating team Pro and Con side, each with supporting material in the take home packet.

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For Safety's Sake: Introduction to Laboratory Safety in Science

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Objectives:

1. To supply students with a list of safety precautions and guidelines as they apply to the science laboratory.
2. To associate the correct laboratory safety rule for the work being done by the students.
3. To identify the type of safety precautions being observed through the use of safety symbols.
4. To practice safety in and out of the science laboratory.

Apparatus Needed:

pictures of safety hazards
safety symbol charts
extension chord
seat belt
fire extinguisher
safety test
first aid kit
safety guideline ditto
student safety contract
safety goggles
apron
step stool
plastic gloves
safety blanket

Strategy:

1. Pictures of safety hazards placed around the room with the following questions attached to each:
   a) What is happening in this picture?
   b) How could this accident have been avoided?
2. Students will move about the room and formulate answers to the questions posed. Answers will be discussed after students have been seated.
3. A display containing the following items:
   fire extinguisher, step stool, extension chord, seat belt.
4. Several students will be asked to pick up an item and stand in front of the picture of the accident that this piece of equipment could have been used to prevent, and then give their reason for making this decision.
5. The students will be given a ditto explaining the guidelines for laboratory safety which they will review with their teacher.
6. A student will be chosen to assist in the proper use of safety clothing and safety equipment.
7. Safety symbol charts will be viewed at this time. Students will be asked to form groups of three (or four depending on class size)

in order to match up the correct symbol(s) with the safety guidelines that were discussed on the ditto sheet earlier.

8. Approximately fifteen minutes before the class is dismissed, the teacher will administer a quiz on laboratory safety.

Assignment:

Students will be required to:

1. design their own first aid kit.
2. prepare a list of ten safety hazards not mentioned in class.
3. have their parents' co-sign their student safety contract and return it to class.

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The Frigid Gourmet

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Objectives:

Students will be able to explain why the freezing temperature of water has to be lowered in order to make ice cream; they will know what chemicals are used to lower the temperature and how each of these chemicals are soluble in water.

Apparatus needed (for a class of 30):

15 graduate cylinders filled with 45 ml of milk, 5 ml of sugar for each cylinder, 3 drops of vanilla for each cylinder, 3 drops of any color food coloring for each cylinder, 15 250 ml beakers, 30 wooden sticks, 30 test tubes, 30 large styrofoam cups, 30 thermometers, 30 small plastic containers, 2 large bags of ice, 500 ml rock salt, 500 ml isopropyl alcohol, 500 ml mineral oil

Strategy:

CHART:

CHEMICALS	EFFECTS ON MELTING POINT OF ICE RAISE, LOWER, OR STAY THE SAME	TEMPERATURE (C)	SOLUBLE OR INSOLUBLE IN WATER	SCIENCE SURPRISE YES OR NO
A. NO CHEMICAL (ICE ONLY)				
B. ROCK SALT				
C. ALCOHOL				
D. MINERAL OIL				

DIRECTIONS FOR MAKING SCIENCE SURPRISE:

Step 1: Pair off with another class member

Step 2: Picking up equipment

- a. You and your partner are to pick up the necessary equipment
- b. Partner 1 - one graduate cylinder, one 5 ml container of sugar, 3 drops of vanilla in cylinder, 3 drops of food coloring in cylinder
- c. Partner 2 - one 250 ml beaker, 2 wooden sticks, 2 test tubes, 2 large styrofoam cups, two thermometers, two small plastic cups

Step 3: At your table, mix the ingredients from the graduate cylinder with the sugar in the beaker and stir with the wooden stick.

Step 4: Pour l/2 of the mixture from the beaker into each test tube

Step 5: Add the wooden stick to the test tube and place the test tube in a styrofoam cup with a thermometer

Step 6: Go back to lab station and have your styrofoam cup filled with ice and one of the chemicals according to your group title (A,B,C, or D)
MAKE SURE THE MIXTURE IN THE TEST TUBE IS COMPLETELY SURROUNDED BY ICE AND MAKE SURE NONE OF THE ICE AND CHEMICALS GET IN THE TEST TUBE

Step 7: Making the science surprise

a. Record temperature of the thermometer (as soon as it stops moving) on the chart
b. Grasp the top of the test tube with 2 or 3 fingers and twist it back and forth in beaker-do not lift it up
c. To see if the mixture is changing, every once in awhile lift up on stick. When the stick starts to stay stuck in the mixture, you know a change is taking place.

Step 8: Remove the test tube from the beaker. Rub between your hands for about 20 seconds.

Step 9: Grasp the stick and carefully remove the mixture from the test tube

Step l0: You have made a science surprise! You may eat it!

Step ll: Looking at your chart, fill in the second column for your chemical only.

Step l2: Pour a little of the ice water (no ice) from the styrofoam cup into the small plastic container. Is it soluble or insoluble? How can you tell?

Step l3: Finish filling in the chart for your chemical only.

EVALUATION QUESTIONS:

l. What was the science surprise?
2. How had the materials in the test tube changed during the experiment?
3. What had to happen to the materials to make a change?
4. Did all the materials change? If so, why not?
5. Results of the chart
   a. Fill in as a class the rest of the chart
   b. Is there a pattern among the materials that changed? What do they have in common?
   c. Which materials lowered the melting point of ice?
   d. Which materials raised the melting point of ice?
   e. With which chemicals did the melting point stay the same?
   f. With which chemicals did one have a science surprise?
   g. What do the chemicals that helped to produce a science surprise have in common?
   h. Name the chemicals (if any) that didn't produce a science surprise. What do they have in common?
   i. What about those mixtures that used ice only. Did they get a science surprise? Why or why not?
   j. Do you think to make a science surprise, the temperature of ice has to change? If so, how will it change?

6. Why can't one make a science surprise with ice alone?
7. Form a conclusion about what is needed to make a science surprise.

BONUS QUESTIONS

l. Why is salt added to the roads in winter to remove ice?
2. Methanol (freezing point is -97.8C; boiling point is 64.7C) was used as an antifreeze in cars. It has been replaced by ethylene glycol (freezing point is -l5.6C; boiling point is l97.6C) WHY?

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GenEng

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Objectives:

Genetic Engineering will explore the basic structure of the DNA molecule, the pairing of base molecules, gene splicing, and re-combining of DNA by chemically removing a segment of DNA from the nucleus of a cell, and inserting it into a plasmid for reproduction.

Students will be able to identify the phosphate and sugar molecules of the DNA strand, pair off the base molecules correctly using a paper model, simulate the removal of DNA segments from a cell nucleus, simulate the chemical cutting or separation along the bases of a plasmid from a bacterium, inserting the donor strand of DNA and inserting the DNA into the plasmid so that it can reproduce with the new, donated characteristics provided by the inserted DNA.

Apparatus Needed:

Duplicated pages (both sides) from "Splice of Life" (Teachers' Guide):

Genetic Blueprint	DNA Replication	Splicing Life
Find The Gene	Lab to Market Maze	Lab to Market
	Glossary	

Recommended Strategy:

1. Orally review the vocabulary listed on the Glossary page.
2. Oral reading of the Genetic Blueprint sheet and completion of activity 2.1 to identify the phosphate and sugar molecules and learn the base pairing rule, A to T and G to C.
3. Oral reading of activity 2.2 (Amino Acid Decoder) to learn which DNA code for bases determines which amino acid.
4. Using a pre-cut DNA Replication sheet (activity 2.3) each group of two students will pair off the "free" nucleotides with the unzipped strands of DNA.
5. Oral reading of the Splicing Life sheet and completion of activity 3.1, matching the DNA strands to sites A, B, or C on the plasmid where the restriction enzymes have chemically cut the bases to permit the simulation of inserting the donated strands of DNA.
6. Oral reading of activity 3.2 (Find the Gene) using the base pairing rule to construct three (3) DNA probes that will bond to the three (3) DNA fragments given.
7. Additional activities (3.3 -Splicing Life Crossword and 4.2 - Lab To Market Maze) can be done by simply following the given

directions.

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PAPER CHROMATOGRAPHY - CHEMICAL AND MECHANICAL

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OBJECTIVES:

To determine all of the pigments present in the chloroplast of a green plant. the student will prepare and read a chromatogram by removing, seperating, and identify the pigments by using a technique called chromatography.

MATERIALS:

test tubes, test tube holder, filter paper (strip type) or chromatography paper, cork, thumbtack, green leaf (such as spinach, geranium,grass or the leaf off a tree), carrot leaves are most suitable. They provide a good source of carotene. Glass pipette, tweezers, scissors, hotplate, small beaker (Pyrex), ethyl alcohol (use denatured.) Acetone may be used to extract chlorophyl from the leaf. A glass rod, water and a solvent which consists of 45 ml petroleum ether, 5 ml acetone, and l ml benzene (this is enough solvent for 20 students)

STRATEGIES:

CHEMICAL PREPARING of LEAF PIGMENTS (May be prepared by one member of your class or the teacher. From this preparation , enough pigment will be made available for the entire class.) Each class member will then prepare his/her own chromatogram.

1. Fill a 600 ml beaker 1/4 full of water. Set this beaker on a hot plate.
2. Bring the water to a boil.
3. Place entire package of spinach (if using frozen spinach) into the boiling water. Bring to a boil again..
4. After one minute, remove the spinach with tweezers and squeeze out all excess water. Then transfer the boiled spinace to a 400 ml beaker containing 80 ml of ethyl alcohol.
5. Heat the beaker by placing it onto the hot plate. Leave it on the hot plate for only about 30 seconds or until the alcohol begins to bubble. Allow the alcohol to cool. Then reboil it several more times.
6. Remove the beaker from the hot plate. Squash the spinach with a glass rod. Reheat and squash until the alcohol solution becomes a dark green color. Enough pigment is now available for the entire class.

PREPARING THE CHROMATOGRAM

Prepare a strip of filter paper chemically as follows:

1. Cut two small notches (one on each side of the strip) about 2 cm from the bottom.
2. Use scissors to taper at the bottom of the paper to a point.
3. Attach the filter paer strip to a cork using a thumbtack and position the strip so that when inserted into a test tube, the filter paper tip just touches the bottom. Adjust the height by moving the strip either up or down on the cork.(The filter paper strip should not touch the sides of the test tube. Trim if necessary.)
4. Dip the fine end of a tiny glass pipette into the pigment solution prepared in the first section.

5. Touch the pipette to the filter paper between the notches. Allow the pigment solution to flow onto the paper.
6. Allow the spot to dry (about thirty seconds). Then add more pigment solution to the same spot. Make 20 applications of the solution. Allow time for drying between applications.

Prepare a strip of filter paper mechanically as follows:

1. DO NOT CUT NOTCHES ON THIS FILTER PAPER STRIP but taper the bottom as in the chemically prepared paper.
2. About 3 cm from the bottom take a leaf you have previously collected and a coin (preferrably a dime)
3. Place leaf on the filter paper and rub the dime across the leaf about six or seven times removing the pigment onto the paper.

SEPERATING THE PIGMENTS:

CAUTION: SOLVENT IS HIGHLY FLAMMABLE. Before proceeding, all flames in the laboratory must be extinguished. Make sure the room is well-ventilated. Do not inhale fumes.

l. Add solvent to a height of l cm in the test tube.
2. Place the filter paper strip into the tube. It is important that the pointed tip just touch the solvent.
3. DO NOT move or shake the tube for at least 15 minutes. Remove the paper chromatogram from the test tube when the level of solvent almost reaches the the top of the paper strip.
4. Examine the chromatogram for the presence of different bands of color. Each color band is a different pigment. You will find the following pigments: CAROTENE - at the top of the paper - ORANGE
   XANTHOPHYLL I - in the middle of the paper - YELLOW
   XANTHOPHYLL II - in the middle of the paper - YELLOW (may be only one yellow band)
   CHLOROPHYLL a - toward bottom - BRIGHT GREEN
   CHLOROPHYLL B - lowest on paper - KHAKI GREEN

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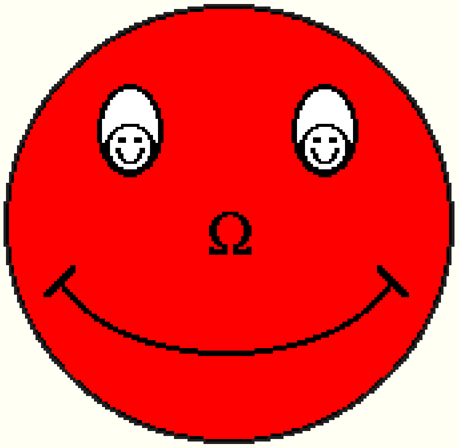
SMILE PROGRAM MATHEMATICS INDEX

The SMILE website is hosted by the Illinois Institute of Technology



The following is a collection of almost 200 single concept lessons. These lessons may be freely copied and used in a classroom but they remain the copyright property of the author(s) and the directors of the SMILE program.

The Mathematics lessons are divided into the following categories: Geometry and Measurement, Patterns and Logic, Probability and Statistics, Recreational and Creative Math, Practical and Applied Math, Arithmetic, Graphs and Visuals, Algebra and Trigonometry, and Miscellaneous.

Geometry and Measurement

- The Pythagorean Puzzle by Earl Zwicker - Illinois Institute of Technology - Dedicated to Prof. Harald Jensen, Lake Forest College
- Areas of States - Estimation by Janice C. Harvey - Carver Middle School
- Liquid Volume by Robert Foote - Disney Magnet
- Spherical Geometry: A Global Perspective by William R. Colson - Morgan Park High School
- Geometry Distance of Triangles using a Protractor by Eileen Lally - A. Philip Randolph Magnet School
- Circles - Diameter, Circumference, Radius and the Discovery of Pi by Kathleen Ryan - Randolph Magnet School
- How To Measure Area by Levi Johnson - James Otis
- An Introduction to Pi and the Area of a Circle by Edwina R. Justice - Gunsaulus Scholastic Academy
- Area and Perimeter by Monica Starks - John Fiske Elementary
- Shapes (Geometric) (Lesson 2) by Violet M. Nash - Spencer Math and Science Academy
- Shapes (Geometric) (Lesson 1) by Violet M. Nash - Spencer Math and Science Academy
- Measurements: Inches by Joyce McCoy - Spencer Math & Science Academy
- Getting To Know You by Kathy Koval - Randolph School
- Inch by Inch and Centimeter by Centimeter Extravaganza by Pamela J. Bates-Hines - Ninos Heroes Academy

- Interior Design by Sally Hill - Horatio May Community Academy
- Maximizing & Minimizing the Area of Rectangles Given a Fixed Perimeter by Tim Amrein - Franklin Fine Arts Center
- Phenomenological Pizza by Robert Foote - Disney Magnet School
- An Introduction To Volume by Linda James Woods - Harold Washington Elementary School
- Measurement of Volume by Richard Murray - Gage Park High School
- Volume and Surface Area by Charlotte Goldwater - Kenwood Academy
- An Introduction to Area and Perimeter by Edwina R. Justice - Gunsaulus Scholastic Academy
- An Introduction to Estimation and Measurements by Christeen Brown - Robert Fulton Elementary
- Circumferences, Diameters, and Radii by Dwayne Belle - Fuller School
- Measuring in Inches and Centimeters by Debra Thomas - Douglass Math and Science Academy
- Estimation by Iona Greenfield - Carnegie Elementary School
- Measurement of Objects Using Similar Triangles in The Plane by John Gabrielson - Chicago H.S. for Agri. Science
- Travel Triangles by Sarah Barrett - Mars Hill School
- Measurement-What is it? by Claudy E. Chapman - Hartigan School
- Finding the Sum of the Exterior and Interior Angles of a Polygon by David Drymiller - Morgan Park High School
- Forming, Measuring and Labeling Angles by Essie Lee May - May Community Academy
- What's My Area? by Karen L. Mickel - William Carter Elementary School
- Geometry and the Geoboard by Jacqueline Darling - Simmye Anderson Community Academy
- An Introduction to Angles by Samuel A. Anoma - Hyde Park Career Academy
- Use A Chair To Teach Math by Laura B. Reed - Rosa L. Parks
- Measurement (cup, pt, qt, gal) by JoAnn Campbell - Leslie Lewis School
- Measurements In The Metric System by Christine Fair - Farragut Career Academy
- The Area of a Circle (Version 2.0) by Edwina R. Justice - Gunsaulus Academy
- The Surface Area of a Cylinder (Version 2.0) by Justice, Edwina - Gunsaulus Academy
- Similarity by Kee, Natalia - Harlan Community Academy H.S.
- Polygons Made To Order by Malone, Loretta - Washington High School
- Properties Of Quadrilaterals by Olson, Margaret A. - Morgan Park High School
- Parallel lines and Angles by Singleton, Earl M. III - Daniel Hale Williams
- The Surface Area of a Cylinder by Justice, Edwina - Gunsaulus Academy
- Soap Film Models by Pintozzi, Joan - Curie Metro. H.S.

- Primary Geometry by Pitra, Barbara - Marconi Community Academy
- Proving Pi by Williams, Gwendolyn D. - Paul Robeson High School
- The Solar System by Fred J. Schaal - Lane Tech High School
- How Many Regular Polyhedrons Are There In This or Any Universe? by Lawrence E Freeman - Kenwood Academy
- The Area Of A Circle by Edwina R. Justice - Gunsaulus Academy

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Patterns and Logic

- M&M MATH by Barbara P. Lorde - Crispus Attucks Academy
- Using Symmetry to Create A Community Quilt by Beverly Brown - Hedges West
- Sorting and Analyzing by Vickie Townsend - Crown Fine Arts Community Academy
- Sorting Through Life! by Barbette Flennoy - Joseph Stockton
- Number Patterns in Pascal's Triangle by Ulysses Harrison - Dunbar Vocational High School
- Visuals Patterns in Pascal's Triangle by Ulysses Harrison - Dunbar Vocational High School
- To Classify Beans And Peas by Gwendolyn Williams - Adam Clayton Powell
- Chess Math by Louis C. Jackson - Lincoln Elementary School
- TESSELLATIONS: An Application Of Simple Regular Polygons by Mary Racky - Kenwood
- Logic and Reasoning by Pearline Scott - Greeley School
- Tower of Hanoi by Paul Eubanks - Washington High School
- Logic by M. Elaine Granger - Irvin C. Mollison
- Counting Triangles by Mamie P. Scott - Coles School
- Using Diagrams in Problem Solutions by Angel L. Torres - Peabody School
- Formula Determination by Odom, Clark - Collins H.S.
- Classification by Wilburn, Delores B. - Shakespeare School
- ="Learning by Logic - Total Surface Area by Boyd, Carolyne - Bennett Elementary

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Probability and Statistics

- Laws of Probability: Mutually Exclusive-vs-Mutually Inclusive Draws by Mikail A. Siddiq - Raymond School
- Probability by Ana Timbers - Stockton
- Probability of Childhood Games by Robert Foote - Disney Magnet School
- Probability by Sandy Reed - Robert Fulton School
- Phenomenological Probability by Robert Foote - Disney Magnet School

- Mean, Median, Mode, etc. by Charlotte Goldwater - Kenwood Academy
- Paper Toss Shootout by Edwina R. Justice - Gunsaulus Scholastic Academy
- Statistics of Mars* by Wilhelm L. Lilly - Kenwood Academy
- Averaging by Sharon Thomas - Emmanuel Christian School
- Probability by Turner, Emily - Joplin Elementary School
- Probability by Moss, Laura Willis - South Shore Community Academy
- Modeling Permutation Group by Mary Margaret Nee - Von Stueben Science Center

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Recreational and Creative Math

- Boomerang by Wilhelm L. Lilly - Kenwood Academy High School
- How Much is a Million? by Sharon Simmons - Joseph Stockton Elementary
- Rocket High by Elizabeth Kelly - Pilsen Community Academy
- Making Ice Cream by Vickie Townsend - Crown Fine Arts Community Academy
- Games Using Multiplication by Amaechi Onyeali - Carter Elementary
- Napier's Rods by Irene Santos - Alexander Graham School
- The Golden Rectangle by Edwina R. Justice - Gunsaulus Academy
- Paper Folding to Make Cubes by Koshy Kanicherilnalil - Chicago Public Schools
- Integer: Tic-Tac-Toe Four In A Row! by Conchita A. Little - Terrell School
- Fractions and Paper Folding by Bill Wagner - Hyde Park Career Academy
- Number Up by Ernestine Bickham - Maria Saucedo Magnet School
- Math Game Using A Tic-Tac-Toe Board by Gertrude Franklin - William Penn
- The Moebius Strip by Arnita Newton - Kenwood Academy
- Fraperdec* by Connie Taylor - Holy Angels School
- How To Use An Abacus by William Gordon - John Hope Academy
- A Fibonacci Primer by Freeman, Larry - Kenwood Academy
- Geometric designs in the game of "Life". by Byrne, Willaim - Martin Luther King H.S.
- Paper Pool by Williams, Barbara - Cook Elementary School
- Graphing Game by Lalagos, Thomas - Hyde Park Career Academy
- Geometric Bingo by Lawrence, Anne - Wells Community Academy

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Practical and Applied Math

- What Does Greatest Common Factor Mean to Me? by Stephen Ha - Lloyd Elementary School

Park Manor

- Ratios and Proportions by Mamie P. Scott - Edward Coles Elementary School
- Draining the Swimming Pool by William Byrne - Martin Luther King
- Sales Tax and Discounts by Denise Folk - Richard E. Byrd Academy
- Mixture Problems by Alphonso Kennedy - Lindblom Tech. H. S.
- An Introduction to Percent by Kenneth Surdell - Lewis School
- Solving Word Problems by Barbara Trotter - O.A. Thorp Scholastic Academy
- Problem Solving: Steps and Strategies by Barrett, Sarah G. - Mars Hill School
- Time by Davenport, Gracie - Spalding School
- Problem Solving by McCree, Marilyn - District 12
- Ratios by Murray, Richard - Gage Park High School
- Learning ratios and proportions through scale drawings. by Laskey, Erwin - Eugene Field School
- Problem Solving by Rogers, Patricia - Edward Hartigan
- Ratio and Proportions by Trotter, Barbara - Ole A. Thorp
- From Hypothesis To Conclusion...Reading Maps To Understand Proofs by Blaszak, Maryann - South Shore Community Academy
- Triangulation by Brandon, Ann M. W. - Oak Forest High School
- Cuisenaire Rods And Math by Linda Easter - Dewitt Clinton Elementary School

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Arithmetic

- Introduction To The Number Line by Sheila Alexander - Manley School
- Extending Our Knowledge of Place Value by Angie Morris - Burnham School
- Filling the Glass (Water, Air, and Fractions) by William R. Colson - Morgan Park High School
- Having Fun working With Fractions by Brian Cagle - John W. Cook
- Number Addition Race by Janice Schaults - Randolph Magnet School
- Lesson for Multiplying and Dividing Fractions with Post It Notes by Robert Foote - Disney Magnet School
- Adding Mixed Numbers with Unlike Denominators by Camille Gales - Edward Coles Elementary School
- Multiplication by Virginia Muhammad - John Hope Community Academy
- Putting the Pieces Together (Making a Fractional Quilt) by Demetria E. McKnight - Bateman Elementary School
- Factors by Edwina R. Justice - Gunsaulus Scholastic Academy

- Place Value by Dwayne Belle - Fuller School
- Percentages by Emma Taylor - Douglass Math and Science Academy
- Counting and Place Value by Carole Gills - Edward Coles School
- Ratio and Proportion by Valesta Cobbs - John Fiske Elementary School
- Introduction to Fractions Using Cuisenaire Rods by Gwendolyn M. Manson - Benjamin Banneker
- Measuring Mixed Numbers by Karen Trout - Sumner Math and Science Academy
- A "New Set of Numbers" (An Introduction of Integers) by Barbara Barlow - Caldwell School
- Primary Understanding and Use of Place Value by Eleanor Brzozowski - Hanson Park School
- Introduction To Equivalent Fractions by Rose Cartwright - Lyman Trumbull School
- Fickled Fractions by Elizabeth Chambers - Keller Gifted Magnet Center
- Addition and Subtraction of Signed Numbers by David Drymiller - Morgan Park High School
- Working with Cuisenaire Rods In Mathematics by Willis Grace - O. A. Thorp Academy
- The Generation Of Fractions by June Muhammad - Park Manor School
- A Method of Front-End Arithmetic by Eddie Newton - Carver Area High School
- Money: Demonstrating Coin Values up to $1.00 by Camille Gales - Coles Elementary School
- How Divine Is My Proportion? by Edwina R. Justice - Gunsaulus Scholastic Academy
- Equivalent Fractions by Gertrude Lockett - Emmanuel Christian School
- Division For Third Graders by Savannah Walker - Mason School
- Prime and Composite Numbers by Charlotte Goldwater - Kenwood Academy
- A Fictional History of Place Value by Bette B. Jarrow - Goudy Elementary
- Fundamentals of Multiplication by Carl D. Mason - Suder School
- Place Value by Ceopal Porter - Dr. Ralph J. Bunche
- Fractions, Simplifying Parts of Shapes -- One-Half, One-Third, One-Fourth by Austin, Sarah - Mary Bethune
- Fraction Message by Harper, Charles - Goldblatt Elementary School
- Identification of Equivalent Fractions by Jarrow, Bette B. - Gaudy School
- Introducing Powers and Models-I by Barrett, Sarah - Mars Hill School
- Math Technique in Multiplication and Division of Fractions by Garth, Frieda - Farragut Career Academy
- Introduction to Fractions on the Numberline by Jones, Claudia R. - Crane High School
- Equivalent Fractions by Williams, Flora - O. A. Thorp
- Introducing Powers And Models-II by Barrett, Sarah - Mars Hill School
- Understanding Fractions by Bradley, Florida - Hartigan

- Odometers and the Place Value Chart by Bronson-Cochran, Donna - George B. Swift
- Basic Mathematical Operations Using Mathtiles by Jones, Claudia R. - Farragut Career Academy
- Adding Integers by Thomas, John Charles - N. F. Simeon Voc. H. S.
- Locating Rational Numbers On the Number Line by Winebrenner, William - Dunbar Vocational
- Continued Fractions With A Calculator by Fred J. Schaal - Lane Tech High School

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Graphs and Visuals

- Collecting Data and Graphing by John Ramsey, Jr. - Morton Career Academy
- Environmental Graphing/Eco Graphs by Chandra E. Price - Burnham Inclusive Academy
- The Ups and Downs of Graphing by Frana Allen - Skinner School
- Teaching Arithmetic and Math Concepts To Headstarters by Jamal Brown - Daniel Hale Williams
- Watermelon Graphing by Shirley Hatcher - Daniel Hale Williams
- History Of Our Solar System on a Time Line by Richard Murray - Gage Park High School
- Graphing Speed by Yolanda Smith - Douglass Math and Science Academy
- History Of Our Solar System on a Time Line by Richard Murray - Gage Park High School
- The Statistics of M&Ms by Charlotte Goldwater - Kenwood Academy
- An Introduction to Data Reading and Computations by Christeen Brown - Robert Fulton Elementary
- Counting And Graphing by Vernita Smith - Mahalia Jackson Elementary School
- Locating IIT Using Ordered Pairs by Diane Yvette Branch - Harold Washington Elementary School
- Collecting Data and Graphing by John Ramsey, Jr. - Teacher's Acad. For Math and Science
- Apples A Peel To Me by Olga Moreno - Horace Greeley School
- History Of Our Solar System on a Time Line by Richard Murray - Gage Park High School
- Locating Points Using Cartesian Coordinates by Mercedes Rodriguez - Clemente Community Academy H. S.
- Getting the Goods on Graphing by Velma Elois Rouse - DeWitt Clinton
- Introduction to Curve Stitching - Line Designs by Wilhelm L. Lilly - Kenwood Academy
- Junk Food Math by Sharon Ross - DeWitt Clinton School
- Rotations by Nash, Susan - Lake View High School
- Graphing Equations From Software by Webb, James - Harlan H.S.

Algebra and Trigonometry

- The Cuisenaire Four-Pan Algebra Balance: Limitations & Suggestions by Bill Colson - Morgan Park High School
- The Pythagorean Puzzle by Earl Zwicker - Illinois Institute of Technology
- Sorting Pennies, A Wagering Activity for Algebra 1 by David Drymiller - Marie Sklodowska Curie Metro H.S.
- Trigonometric Functions by Lesia Smith - Michael M. Byrne School
- Equalities And Inequalities by Perry Lemon - Shoop School
- Draining The Swimming Pool by Byrne, William - Martin Luther King H.S.
- Inequalities by Butler, Ben Jr. - Gage Park High School
- Linear Equations by Ennis, Beatrix U. - Senn Academy High School
- Algebraic Addition by Junievicz, Alex - Kelly H.S.
- Simplifying Equations of the Form ax+b=cx+d by Wagner, William F. - Hyde Park Career Academy
- Rules of Sign Change by Zuger, Joel P. - Chicago Metro High School
- Using the Balance by Davis, Marie - Marconi Community Academy
- Multiplying and Factoring Polynomials Using Algebra Tiles by Marshall, Regina - Curie Metro High School
- Vision Props of Signed Numbers by McMiller, Mable - South Shore High School
- Positive and Negative Numbers by Siegel, Lincoln R. - Cregier High School
- Positive-Negative Charge Model For Integers by Williams, Barbara - J. N. Thorp School
- The Sine Function by Ronald G. Sienkiewicz - Prosser Vocational High School
- Visual Structure of Postulates and Axioms in Algebraic Operations by Sanford Olshan - Roosevelt High School
- Introduction To Solving Equations by Mary Lynn Bochenek - Central Junior High
- Order Of Operations by Bernice E. Holloway - Bellwood School District #88
- Commutative, Associative And Distributive Properties by James E. Breashears - Robeson High School

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Miscellaneous

- It's About Time by Vernita Smith - Mahalia Jackson Elementary School
- Multiplication and Areas by Albert Michael - Robert Fulton Elementary School
- Zone Out! by Willie Mae Wilson - Hartigan Elementary School

- Elapsed Time by Bernice Joyce Henry - Edward H. White
- Telling Time in Different Time Zone by Borita Khim - Stockton Elementary School
- Area, Arithmetic and Algebra by Larry Freeman - Kenwood Academy
- Area, Arithmetic and Algebra by Larry Freeman - Kenwood Academy
- Tony's Tiger BITES by Maudestine McLeary - John Hope
- Properties of Numbers by Steinfelds, Leon - King High School
- Make-and-Take: Staff Development by Pintozzi, Joan - Curie Metro. H.S.
- An Introduction To Sets by Belton, John P. - Jones Metro. H. S.
- Discovering New Units by Jenkins, Kay - James Shields Elementary School
- Play Ball by Roslyn N. Matthews - South Shore High School
- Using Variables And Ratios To Get You In The Right Gear by George K. Smith - Dunbar VHS

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Mathematics/Physics

Areas of States - Estimation

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Objectives:

Students will learn how to use the formulas for measuring the area of simple geometric shapes to estimate the area of an irregular shape**.** Students will learn how to estimate the area of the states using the formulas for the areas of rectangles, squares and triangles. This lesson is designed for seventh and eighth grade students.

Materials:

Each team will need these materials. (Students will work in pairs.)

- Outline maps of individual states with distance scales.
- Rulers
- Calculators
- Pencils
- Paper
- List of areas of all 50 states

Strategy:

Review the formulas for finding the areas of rectangles, squares, and triangles. Remind students that in real life measurement situations, it is often easier to use estimation. Choose an irregularly shaped, flat object or draw an irregular shape on the board. Demonstrate to the students how the shape can be divided into sections. Approximate each section with a rectangle, square or triangle.

These formulas may be used:

- Area of a rectangle =length ´ width
- Area of a triangle = 1/2 ´ (base) ´ (height)
- Area of a square = $(side)^2$

Have students, working in pairs, choose a state and estimate the area of that state by using different shapes. They may estimate the area of the state by using the formulas for finding the area of the various shapes, and by referring to the scales on the maps.

-

Performance Assessment:

As a performance assessment for this lesson, give each student an outline map of a state to estimate the area of that state. Student's final estimation should be within an 80% accuracy range.

Conclusion:

-

By using the formulas measuring the areas of simple geometric shapes and the map scales, the students will be able to estimate the land area of certain states.

-

References:

- Ready to Go US Outline Maps [Scholastic Professional Books – 2000]
- Passport to Algebra and Geometry [McDougal-Littell 1999], pp. 192-193
- Road Atlas [Rand McNally 2000]

Mathematics/Physics

Liquid Volume

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CHICAGO IL 60613

Disney Magnet
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Objective(s):

Students will learn and use formulas for the volume of a rectangular prism and volume of a cylinder.

Students will see the relationship between cubic centimeters and milliliters.

Students will compute formulas with and without calculators.

This lesson is designed for a junior high classroom.

Materials:

Depending on how many students you will use for this project, the amount of materials vary. If you break students up into small groups, you should use one of each of these materials in each group.

1. Plastic graduated cylinder measuring milliliters

2. Different size cylindrical containers such as coffee cans, Pringles potato chip cans, cookie tins, and the like. (Make sure these are made of a durable material that can hold water without falling apart. Cardboard is not good.)

3. Different size rectangular prism containers such as plastic storage containers, tins, and the like. Make sure the base is either square or rectangular.

4. Water

5. Food dye (Optional)

6. Rulers or tape measures

7. Calculators (optional)

Strategy:

At the beginning of the class, go over the formulas for finding the volume of a rectangular prism; that is base times height or length times width times height. Explain that the basic formula (base times height) also applies to the volume of a cylinder, except that the base is now a circle so the formula for the base is Pi multiplied by radius squared. Then multiply the base times the height. Once students are comfortable using these formulas, take one of the smaller rectangular containers and have students measure the length, width and height in centimeters of the container using tape measures. (DO NOT TELL THEM HOW TO MEASURE. This will lead to interesting discussion.) Once they have measured the sides, compute the volume. Your answer will be in cubic centimeters. This is the same as milliliters since there are 1000 cubic centimeters in a liter and 1000 milliliters in a liter. Once the volume is computed, measure the water in milliliters to see how it compares to the computed volume. If all is done correctly, you should have a close match. If the water overflows or the container is not completely full, a mistake was made. Elicit a discussion with your students to see why this happened. After showing how to do one to the class as a whole, then break up the class into groups and have them do two containers per group (One cylinder and one rectangular prism). After they have measured and calculated as a group the volume of their containers, let them check the volume with water. Observe as they measure and pour to determine accuracy of calculations and measurement. First calculate using the formula, then check using water. At the end of the class, discuss each of your findings and any problems you may have had. To more clearly see and measure the water used in this lesson, you may elect to use drops of food dye in the water.

Performance Assessment:

As a performance assessment for this lesson, give a child a container of each type to calculate the volume. Then have the child measure and pour the water into the containers to check his or her work. This lesson in itself is a performance assessment.

Conclusions:

Students should conclude in the end of this lesson that the formula for volume in cubic centimeters comes very close to the actual volume of the container in milliliters. They should also be able to detect what went wrong if a mistake occurs.

References:

The Only Math Book You'll Ever Need by Stanley Kogelman, Ph. D. and Barbara R. Heller, M. A., 1993, revised edition, page 143.

William R. Colson - Morgan Park High School

Spherical Geometry: A Global Perspective

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Objective(s):

Suggested Grade Level: 3-12

1) Relate prior knowledge about the globe to definitions and properties in spherical geometry.
2) Given a common definition or property in Euclidean geometry, make a conjecture about the corresponding statement in spherical geometry.

Materials Needed:

Clear, inflatable globe (optional: 1 small globe per group)
Index cards (1 per group)
Chalkboard/whiteboard with compass and meter stick
Optional:
Apples or white styrofoam balls (1 per group)
Paring knives or black markers (1 per group)
Lenart sphere (kit available from Key Curriculum Press)

Strategy:

Begin with a review of terms and definitions from Euclidean (conventional) geometry. This should be done through questioning, not lecture, in order to assess prior knowledge. Students should at least have a basic understanding of points, lines, and planes for this lesson to be appropriate. Particular content, including properties to be investigated, will be chosen according to the knowledge and grade level of the students.

Split the class into groups of 3-5 students. Produce a clear inflatable globe containing latitude and longitude markings. Have a general discussion about latitude and longitude. If available, give each group a small globe of some type to use for individual reference. Compare to a flat map. What is different about the latitude/longitude markings?

Eventually, someone should note that on the globe, latitude/longitude markings are not lines, but circles; then, that latitude circles are of different sizes, while longitude circles are all the same. Using the list of terms developed in the opening discussion, identify corresponding parts on the surface of a sphere and give their accepted names in spherical geometry (see List #1 below).

When the class seems comfortable with the new terms, give each group an index card containing a statement of a postulate or property in Euclidean geometry and instructions to translate it into a corresponding statement in spherical geometry (see List #2 below).

Depending on class level and time available, follow-up activities could include such things as:

1) What would a spherical ruler/compass/protractor look like?
2) If parallelism does not exist in spherical geometry, can we still construct figures that correspond to parallelograms? What would be their properties?
3) What about spherical "triangles"? What would correspond to acute, right, or obtuse? What could we say about angle sums? Is there anything corresponding to the Pythagorean theorem?

In my class, I gave each group an apple, a paring knife, and the following instructions: "Cut your apple to represent a spherical 'triangle'. Do this by scoring an 'equator' and one or two great circles through the poles. Question: What is the possible range of the sum of the measures of the angles of the triangle? (Answer: Greater than 180º and less than or equal to 360º.) If they gave and explained a satisfactory conjecture, I gave them a small cup of caramel dip and permission to slice and eat their apple. If knives and food are inappropriate for your classroom, this activity (as well as many others) may also be done using a white styrofoam ball and black marker.

List #1
Corresponding terms (examples):

Euclidean	**Spherical**
point	same ("polar" points are endpoints of a diagonal of the sphere)
line	great circle
plane	sphere
ray	none
line segment	arc of a great circle
angle	angle (intersection of two arcs)

List #2
Corresponding statements (examples):

1) E: There is a unique straight line passing through any two points.
   S: There is a unique great circle passing through any pair of nonpolar points.
2) E: If three points are collinear, exactly one lies between the other two.
   S: If three points are collinear, any one of the three points is between the other two.
3) E: The intersection of two lines creates four angles.
   S: The intersection of two great circles creates eight angles.
4) E: If two lines are parallel to a given line, they are parallel to each other.
   S: There exist no parallel lines.

Performance Assessment:

1) Individual responses when matching corresponding terms.
2) Group discussion and presentation of corresponding statements.
3) Group discussion and presentation **or** individual write-up of conjecture reached in follow-up activity.

Conclusions:

Depends on particular content chosen. In general, they should conclude that most, but not all, terms and properties in Euclidean geometry have counterparts in spherical geometry. More advanced students may be asked to discover properties unique to spherical geometry.

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Geometry Distance of Triangles using a Protractor

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Objectives:

Students in the 7th grade are to learn how to use the protractor to measure angles, and use this ability to solve a problem involving distance.

Materials Needed:

Protractors for each student
Rulers and meter sticks
Straws and clay

Strategy:

PART ONE

1. Identify the vocabulary: ray, angle, vertex, unit of measure, protractor
2. Demonstrate or review how to use the protractor.
3. Draw a 60cm line labeled AB on the board. Instruct students to draw a 6cm line labeled ab on paper.
4. At point A/a make a 35º and at point B/b make a 60º. Make sure that the rays are extended until they cross. Label that point C.
5. Compare the triangles (the one on the board and the one on paper). These triangles are similar.
6. Present the question: What is the distance of the line segment AC without leaving your desk?
7. Set up the ratio: line AB over line ab = X (AC) over line ac.
8. Now measure the line AC and compare the result with the calculated answer. Use the formula: Actual measurement minus Calculated measurement divided by Actual to obtain the margin of error.

PART TWO

1. Upon a large table, mark two points A and B and determine the distance (AB) between them.

2. Use the protractor to determine the measure of angle BAC. Likewise, determine the measure of angle ABC.

3. We now attempt to determine X, the distance (AC) from the point A to the Point C. Make a model (as described in Part 1) keeping the angles found but reduce the size of line segment ab. Set up the ratio: Line AB over line ab = X (AC) over line ac.

4. To verify, measure the distance from point A to point C. Compare with the calculated answer. Use the formula: Actual measurement minus Calculated measurement divided by Actual to obtain the margin of error.

Performance Assessment:

A similar problem like part two can be used as a performance assessment. The students are to answer the following question. What is the length of line AC?

Conclusion:

Knowing two angles and the distance between them, you can find the distance of the point that completes the triangle. This can be done by making a smaller model to help calculate the answer.

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Circles - Diameter, Circumference, Radius and the Discovery of Pi

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Objective:

This seventh grade math lesson is designed to help students identify and measure the diameter, circumference, and radius of a circle.
The students should discover the approximate value of pi through the relationship between the diameter and circumference.

Materials Needed:

Various size circles, meter sticks, metric tape measures, rulers, scissors Scotch tape, drywall tape, calculators, and table worksheet.

Strategy:

1. Identify the diameter, circumference, and radius of a circle.
2. Demonstrate for the students how to measure the diameter and circumference on a circle. Explain that radius is half of the diameter.
3. Six various size circles are labeled A-F. Include many samples of the same size circles.
4. Working in pairs or in groups have the students record the diameter and radius of each circle using a ruler, tape measure, or meter stick using centimeters. This information is recorded on a table worksheet.
5. The students then measure the circumference using drywall tape. The drywall tape is placed around the perimeter of the circle and marked with a pencil and then cut. The drywall tape is then measured on a ruler, tape measure, or meter stick. The circumference is recorded on the table worksheet.
6. After the students have recorded the information for circles A-F, ask the students if they see a relationship between the diameter and circumference.
7. Divide the circumference by the diameter for each circle.
8. Discuss the results of circumference divided by diameter.
9. Compare the class' results with the standard value of pi(3.14159265...). Write the symbol for pi (p) on the chalkboard.

Performance Assessment:

The students will measure the diameter of a record album or another circular object (other than the previously used circles) and predict the circumference. The students will then measure the circumference of another circular object and predict the diameter.

Conclusion:

The students should have a clear understanding of the relationship between circumference and diameter and be able to apply this knowledge to similar situations.

NAME____

CIRCLES	DIAMETER	CIRCUMFERENCE	RADIUS	
A				
B				
C				
D				
E				
F				

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How To Measure Area

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Objective:

The seventh graders will demonstrate an understanding of square units.

Materials Needed:

twelve inch rulers, floor space in the room at least 4 feet by 12 feet, rectangular objects

Strategy:

Have an individual demonstrate the amount of space covered on the floor in one square foot. The student will take four twelve inch rulers placing them tip to tip to form a square. The measured space is a square foot. Ask the class how many individuals can stand in the square foot region. They will immediately discover the answer.

Now designate a larger square region of the floor. Ask the class to determine the number of students required to fill the space (i.e., by standing within it). Have the students make connecting squares within the region. They continue to make squares with one foot sides until each person has his or her own square. At this point they have proved for themselves the answer to the above question.

Additional application is needed to get a full and thorough insight into area. Give each student several surfaces to measure the area of. The teacher should determine the particular units to use. In my own lessons, measurements are done using either the English or metric system. Whenever a student arrives at the probable answer, he or she comes to me and asks for a piece of drywall tape the exact size required to cover the area. It should be noted that the teacher may use any kind of material suitable for covering the surface. Some of these activities can be done as individual or group projects. When the activity is complete students will have valid evidence of the concept of area.

Performance Assessment:

Any student who gets the correct measurement of the area of all the objects, solves the problem mathematically, and is able to explain in writing what went on receives a grade of A. A grade of B will be earned by students who know the mathematics and can almost fully explain what took place in written form or words. A grade of C will be earned by those who measure accurately, can do most but not all of the mathematics and can give reasonable explanations about what took place. Anyone else will have to repeat the exercise.

Performance Assessment:

Students will each measure several smaller items to find the area in square inches. As they complete measurements, they come to me to request that many square inches of drywall tape. Then they will cut the material into one inch squares to place on the object. If their measurements and mathematics are correct, and they cut the paper right, they should not be under nor over in the amount of tape.

Conclusion:

After following these directions and procedures to arrive at an answer, students should have discovered a good deal about area.

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An Introduction to Pi and the Area of a Circle

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Objectives (Staff):

* Demonstrate a phenomenological approach to teaching mathematics
* Inspire others to use the approach

Objectives (Grades 5-7):

* Observe and discuss the relationship between circumference & diameter and how that relationship, called pi, is used in the formula for the area of a circle.

Materials:

round container lids with varying circumferences
4-column math table (label: **circumference**, **diameter**, **c/d**, & **lid** #)
graph (label - horizontal axis: diameter; vertical axis: circumference)
small circle drawn on centimeter grid
small circles
metric tape measures
calculators
glue

Recommended Strategy:

* Count square centimeters inside circle and estimate the area.
* Draw a square outside the circle. Calculate the area of the square.
* Draw a square inside the circle. Calculate the area of the square.
* Estimate the area of the circle by relating it to areas of the outer and inner circles.
* Cut a small circle into 16 equal pie-shaped pieces. Arrange these pieces to form a parallelogram and glue them on centimeter grid.
* Calculate the area of the parallelogram made with the pie-shaped pieces.
* Measure circumference and diameter of lids and record on 4-column math table.
* Divide circumference by diameter and record.
* Plot ordered pairs (diameter, circumference).
* Discuss graph.

* Discuss results of C/D.

* Roll large lid or trundle wheel on board and mark circumference. Show how diameter relates to it.

* Show how the area of the parallelogram, made from 16 pieces, is equal to (pi)r^2:

Area = base x height	Note: c/d = (pi)
= 1/2 circumference x radius	c = (pi) x d
= 1/2 [(pi) x 2r] r	d = 2 x r
= (pi)r^2	c = (pi) x 2r

* Use formula to calculate area of initial circle. Compare to estimates.

* Estimate areas of other circles and then calculate actual areas and compare to estimates.

Performance Assessment:

This is an introductory lesson. It is not necessary to assess usage of area of circle formula at this time.

Ask the following question:

"What mathematical relationship does pi represent?"

Students should write responses on paper. Collect, read, and assign a rating to each.

Expected responses:

The circumference of a circle is 3.14 times its diameter. This relationship is called pi.

Pi represents the circumference of a circle divided by its diameter.

Pi = c/d.

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Area and Perimeter

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Objectives:

This lesson is designed for the intermediate grade levels. Upon completion of the lesson students should be able to:

* use with accuracy this unit of measurement
* differentiate between area and perimeter
* compute the area and perimeter of an object

Materials:

* posterboard cut in squares, rectangles and triangles
* rulers
* scissors
* a bolt of lace trim
* velcro and magnets
* skin area worksheet-See references
* 3x5 index cards
* worksheets with geometric shapes using various units of measurement to calculate area and perimeter.

Recommended Strategy:

* Ask opening questions:
  When do we use the measurement of area?
  When do we use the measurement of perimeter?
  How would you measure a shape to trim it in lace?
* Do worksheet on area and perimeter on the overhead as the students work at their seats.
* Distribute and explain skin area worksheets then pair off students.
* Students will complete and turn in the skin area worksheets.
* Distribute materials for perimeter activity.
* Ask students how they would measure the shape of the picture frame to trim it.
* Students will use their rulers to find the perimeter of their shapes.
* Perimeter calculations are put on 3x5 index cards.
* Students will use their ruler to cut the length of lace from the bolt.
* Students will glue the lace on the perimeter of the shape.
* Place the velcro or magnet on the back of the picture frame or a cake can be placed on the rectangular shape.
* Ask the closing questions:
  You want to tile your kitchen floor. Which measurement do you use?
  You want to fence in your garden. Which measurement do you use?
  Students will record their answers on the 3x5 index cards.

Performance Assessment:

If the lace frames the perimeter of the shape without overlapping then the perimeter was calculated correctly. Check answers to the closing questions on the index cards. Also, check the calculations on the skin area worksheets.

References:

Everyday Mathematics Journal II, Everyday Learning Corporation, 1995

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Shapes (Geometric)

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Objectives:

Students will be able to illustrate various geometric shapes such as a triangle, square, and rectangle on a one inch square grid using pennies. Designed for second grade.
Students will be able to demonstrate how to make a one dimensional vest using butcher block paper and various fabrics. Designed for seven and eight grades.

Materials Needed:

Ten pennies per student
One inch square grid (8"x10" sheet of paper)
One square yard of butcher block paper per student
Markers
One yard of fabric (various widths or lengths) per student
Scissors
Clear tape
Scratch paper
Neon paper
Shape packet-square (2"x2"), rectangle (3"x5"), and triangle (6")

Strategy:

Demonstrate to class, using a 20"x20" sheet of paper, how to cut a round, square, scallop, or triangle shape neckline. Cut the paper in half to form two rectangles. Explain to class that they are going to be a designer and creatively style their own vest. Show drawings of several designs to class.

Activities:

1. Give each student ten pennies and a grid sheet
2. Using pennies and grid sheet, instruct students to illustrate the shape of a triangle, square, and rectangle
3. Allow students to select a partner and give each person a sheet of butcher block paper and a piece of fabric
4. Have students select a partner (approximately the same height) and give them a marker, scissors, a shape packet (cut from neon paper), and tape
5. Tape paper to wall and with marker trace outline of partner's body from the waist up
6. Students are to create their own custom design vest and tape to butcher block paper

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Shapes (Geometric)

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Objective:

The student will be able to identify geometric shapes using colors and math problems. Designed for second grade.

Materials Needed:

Magic Marker (black or navy)
Neon Construction Paper (five colors)
Index Cards
Magnetic Tape
Scissors
Name and Diagram of eight geometric shapes:
   Circle
   Square
   Diamond
   Rectangle
   Triangle
   Hexagon
   Octagon
   Pentagon

Strategy:

Cut out each of the above shapes in five different colors (40 shapes).
Cut one extra set of shapes with the proper name that correctly identifies that shape and use for demonstration.
Write primary math problems (using four operations) on index cards, select four exact answers per problem, and tape a card to back side of neon paper.
Using magnetic tape, scatter 40 designs and attach to magnetic board.
Divide class into two equal teams, one captain per team, and designate playing area for each team.
Place demonstration shapes beside (for reference) scattered shapes.

Activity:

Alternate one player from each team to call the color and shape (e.g. yellow hexagon and blue pentagon) and the captain of that player's team will turn the cards over to show math problems. Player must state the problems and the answers. If the answers are a match (e.g. 5+5=10 and 20-10=10), that player continues to play until no match is made. As the first player moves to the end of their team's line, play begins with the next person in line on the opposite team. Points may be assigned by giving a number value for every match obtained. The team with the highest number of matches or the most points is the winner.

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Measurements: Inches

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Objectives:

This lesson is designed for the primary grades.

Solve problems involving measurement using information taken from various items measured.

Students will be able to measure to the nearest inch.

Students will be able to identify the length and width of rectangles.

Students will be able to write simple addition problems.

Students will be able to perform simple addition of two one-digit numbers.

Materials Needed:

wooden blocks of various sizes (squares and rectangles)
empty boxes of various sizes
12-inch ruler
tape measure
chalkboard
chalk
Word list: ruler, tape measure, block, square, rectangle, box, sum, add, addition, wide, width, length, height, measurement, plus, equal, close, closest, long, longest, large, largest, short, shortest, tall, tallest, results

Strategies:

Using a 12-inch ruler, there should be no results over 12. The purpose of measuring items is to link the concept level and the symbolic level. Measurements can be linked with addition. Display a 12-inch ruler and have students identify it. Explain that an inch is a customary unit used to measure length and width. Stress that the distance between numbers on an inch ruler is 1 inch. Ask: How do you measure with an inch ruler? (Line up the left end of an object with the left end of the ruler and see how long the object is.) Work independent with several students. Point out that about how many means measuring to the nearest inch, not to the exact inch.

Procedure:

One student can come to the front of the room and measure the length and width of an item. The teacher or student will write both of the numbers on the chalkboard. The two numbers are written as an addition problem. The same student will write the correct answer on the chalkboard. If student is unable to add the problem, the student will use the unifix cubes to find their answer.

The student can use the tape measure to measure the length and width at the same time to check an answer. Have enough items so that each child can participate.

Extension:

Students can write the ten problems down on a piece of paper. Use number skills to observe the associative and commutative properties of addition. Example: 3+4=7 and 4+3=7. Students can make a written record of their combinations using all ten problems.

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Getting To Know You

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Objectives:

This lesson can be easily adapted for all grade levels. Upon completion of this lesson, the students will be able to do the following:
-Use a ruler and measure accurately to the nearest inch.
-Draw and label properly different graphs (line, pie, bar, pictograph)
-Estimate/record measurement on number line using intervals.
-Collect data and analyze

Materials:

-Tape measures
-ribbon (one per child)
-post-its (two per child)
-scissors

Strategy:

Students work with a partner for this activity. You may want to have tape measures already pretaped to a wall. Some taped in a horizontal fashion to help assist measurement in arm span. Others taped in a vertical manner to assist the measurement of height.

-One student measures his/her partners arm span (finger tip to finger tip).
-Record this information on a post it.
-Measure partners height. Record information on same post-it.
-Cut a piece of ribbon to the height of partner.
-Use second post-it and record height only in large print.
-Switch roles of partners.
-After students are finished with measurements, students are to hang their ribbon on the wall according to height. The ribbons should hang from smallest to largest. Students should also identify their ribbon with their post-it that states their height in large print. (You may want to have cards with measurements already established in intervals of six inches to help assist students in finding "their" place on the classroom number line).
-When all students are finished, the teacher can help students use the information to graph.
-Demonstrate to students that all graphs need a title and x and y axes.

Graphing

Bar graph
(Use graph paper on overhead) Have students suggest title for graph. Now fill in information on x axis (height). Write in measurements from smallest to largest. The y axis will represent the number of people. Show students how to fill in bar graph as they complete a copy at their seat.

Pictograph
Create title and the x and y axis with the students.
Have students draw a long rectangle, square, or short rectangle on their post-it (the one with arm span and height measurements). This shape should represent their body shape.

Long rectangle	height > arm span
Perfect square	height = arm span
Short rectangle	height < arm span

Call students up by rows to place their post-its on the pictograph according to body shape.

Pie graph
Remind students that a pie graph represents the class as a whole, each section represents one student. Have a pie graph already sectioned according to the number of students in the class. Color code body shapes with a color chart.
Example: perfect square = blue
long rectangle = red
short rectangle= yellow

Have a student come up and color the pie graph accordingly.
You may want to glue this circular graph onto a large sheet of paper and write all of the necessary information on the sheet (title, color code).

Performance Assessment:

Students would decide what topics, ideas they would like to graph in class. (Types of pets owned, favorite tv show, sport, game, etc, number of siblings.) Students can break into pairs and interview or write a short questionaire for their classmates to complete. Students would have a time frame to gather information and then come up with a graph that would best portray the information gathered. Students would need to decide what type of graph would best meet their needs. Display graphs around the room and discuss information.

Enhancement:
Ask students how you sectioned off the pie graph so that each section has the same size. Introduce a protractor and the measurement of a circle is 360 degrees. Give students a paper plate and protractor and have them work in groups of 5. Tell them to evenly divide the paper plate into 5 equal pieces and draw their favorite pizza topping on their section.

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Inch by Inch and Centimeter by Centimeter Extravaganza

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Objectives:

Kindergarten-Primary
* Students will be able to measure one inch to a yard.
* Students will be able to measure one centimeter to a meter.
* Students will be able to compare and contrast standard to non-standard units of measurement.

Materials Needed:

12 inch rulers
36 inch yard sticks
30 centimeter rulers
meter sticks
measuring tapes/centimeters and inches
graph paper/centimeters
graph paper/inches
finger or tempera paint
string
ditto copies of a 12 inch ruler
ditto copies of a 30 centimeter ruler
paper-made flowers
transparent tape
chalk
poster or bulletin board
colored markers
manipulatives
scissors
glue
candy Twizzlers

Strategy:

Ask questions to enhance metacognition and elicit meaningful responses:
How do we know that the Sears Towers is the tallest building in the city of Chicago?
How do we measure things?

Make two marks approximately 12 feet apart on the floor or ground.
Have students pace, walk, skip, hop (by student choice) from one mark to the other.

Discuss with the students to elicit that we could measure people, places, and things to determine lengths, width, and height.

Distribute 12 inch rulers.
Distribute copies of a 12 inch ruler.

Have students compare and contrast the paper copy to the actual ruler.
Precut or have able students cut 12 1-inch squares.
Have students align paper square inches above the copied ruler.
Have students compare and contrast paper square inches to the copied ruler.
Have students recognize that there are 12 inches in a foot.
Have students glue the square inches above the copied ruler.
Then have the students press a thumb in a container of fingerpaint and make thumbprints under the copied ruler.
Have students compare and contrast how many of their thumbprints it took to equal one foot.
Have students make the conclusion that this is one foot of thumbprints.

Additional Activities:
AA-1 Distribute copies of 30 centimeter ruler.
Have students compare and contrast centimeter ruler to copied ruler.
Have students compare and contrast centimeters to inches on the ruler and copies of the rulers.
Have students measure candy Twizzlers and make a record of the length in centimeters.
AA-2 Have students use rulers to measure four sided geometric objects.
AA-3 Distribute manipulatives to the students.
Have students determine in inches and centimeters how many manipulatives it takes to cover the length of 12 inches and/or 30 centimeters.
AA-4 Predraw or mark lines of different lengths on the ground or floor. Group students and have them measure and record lengths.
AA-5 Distribute copies of inch or centimeter graph paper.
Have students make handprint or footprint on the graph paper.
Then have students count the squares of area.
AA-6 Have students form partners.
Distribute two pieces of string to each group.
Direct students to measure the length of each other's arm with the string.
Have students measure the string with 1-inch squares .
Then have students attach their string to a paper flower with their names and lengths on them.

Performance Assessments:

AA-1 Have students tell or write the number of centimeters in the length of the candy.
AA-2 Have students tell or write the measurements of each side of the geometric objects.
AA-3 Have students tell or write how many manipulatives they had to use to measure 12 in. and or cm.
AA-4 Have students tell or write how many in. or cm. the lines measured.
AA-5 Have students record the number of in. or cm. in the lengths of their hand or foot.
AA-6 Make a board displaying the students' flowers showing in. and cm. scales. Have students graph 5 students' flower measurements on a pictograph.

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Interior Design

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Objective:

This lesson is designed for intermediate grades 4-6. The students will be able calculate area and perimeter in inches.

Materials Needed:

* 4 Cardboard Walls (approximate size 36X50)

* Scissors

* Glue or glue sticks

* Wall paper or wrapping paper

* Measuring utensils (measuring tape, ruler, yard stick)

* Writing Utensil (pen/pencil)

* Play money

Strategy:

The teacher will supply 4 walls of identical sizes from a large cardboard box which will represent each direction, (North, South, East and West). The walls will have a minimum of 1 opening with a geometric shape to show a window, door, clothes hook, wall vent, enclosed bookcase, etc. The students will be divided into 4 groups and instructed to cover their wall. Each group will be given $50 and the materials needed to complete their wall.

A store will be set up where the students can purchase wall paper. The students must determine the amount needed and compute tax on their purchase. The students will determine the best buy via purchasing paper from pre-cut rolls or by the foot.

The students will calculate the area to be covered by finding the total area of the wall in inches and subtracting the area of the opening. Using the $50, each group will purchase wall paper based on their calculations. After purchasing the paper, the students will transfer the wall measurements to the paper, cut, and cover the wall. (The student will problem solve when determining the best way to cover the wall with the paper allowing for the doors, windows, etc).

Each group will also be asked to determine the amount of border needed to cover the top of the room. (They will multiply the width of their wall by 4). All completed walls will be put together (matching directions) and wall border will be applied in a continual piece based on the amount computed by the groups.

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Maximizing and Minimizing the Area of Rectangles Given a Fixed Perimeter

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Objectives:

Grade Levels 5-8. (This activity can be simplified for younger, less mathematically mature students. Numerous extensions can be added for more advanced students.)

(1) Students will analyze and solve problems in which rectangles with identical perimeters are compared to maximize or minimize area.
(2) Students will analyze problems by collecting data and searching for patterns and generalizable relationships.
(3) Students will represent problem situations with models.
(4) Students will analyze fixed perimeter problems using x,y coordinate graphing.
(5) Students will find fixed perimeter rectangles with maximized or minimized area using qualitative and quantitative analysis.

Materials Needed:

(1) A fixed length of ribbon, or string, which will be used to represent a fixed length of fencing
(2) Paper or cardboard rectangles of given, fixed perimeter
(3) Tiles, ceramic or paper
(4) Inch tiles (tiles with 1 sq. in. area)
(5) Scientific calculators
(6) Graph paper
(7) Handouts with problems involving fixed perimeter and, if students have prior experience with it, fixed area.

Optional materials:
(1) Fixed lengths of actual fencing

Strategy:

(1) Students will be given 3 paper rectangles with identical perimeters (such as 5 in. by 25 in., 10 in. by 20 in., and 15 in. by 15 in.) They will additionally be given 5 in. tiles (square tiles whose sides are each 25 sq. in.) Give the following instructions and questions: (1) Use your ruler to find the perimeter of each rectangle. (b) What do these rectangles have in common? (c) Which rectangle requires the most tiles to completely cover it? (d) Which rectangle requires the fewest tiles to completely cover it? (Students will work in pairs)
(2) Next, the students will be presented with this problem, "You have a plot of land and a dog. Your dog has run away a couple of times and often runs on your neighbors' property. You decide to fence in a rectangular section of your land so that your dog doesn't run away but has room to play. You have 72 feet of fencing. You want each side of the rectangular "pen" to be a whole number in length. Your goal is to allow your dog the maximum amount

of space to run around and play. Design the rectangle that achieves this goal." The students will model this problem using a length of string or ribbon 72 cm. long. Students are to experiment with at least 5 different rectangles. They are to record the dimensions (bottom edge, side edge, perimeter, area) for each of their fence models. We will then discuss the fact that, geometrically speaking, we are maximizing area given fixed perimeter. (Students will work in pairs or in groups of four)

(3) Next, the students will be presented with these two problems:
   (i) "You run a business that puts on banquets. For one small banquet, you need to seat 12 people. You construct your banquet tables from small square tables (which individually seat 1 person on each side). Each small table costs your company $1 per day (for rental or moving). Your banquet tables are always rectangular.
      (a) What are the dimensions of the table that will seat these 12 people most cheaply?
      (b) What are the dimensions of the table that would seat the 12 people in the most expensive way possible?
   (ii) The same basic problem will be repeated for a banquet in which 24 people need to be seated.

   For both of these problems, charts will be compiled in which the dimensions (bottom edge, side edge, perimeter, and area) are recorded for all possible perimeter of 12 and perimeter of 24 rectangles.
   Fixed perimeter coordinate graphs will be completed recording the bottom edge and area ordered pairs (separate graphs for P = 12 and P = 24).
   The shape of these graphs and the information they give will be discussed. (The points can be connected to form parabolas. The area optimizing square and the two area minimizing rectangles will be evident on the parabolic curve.) (Students will work in pairs or groups of 4)

(4) Similar problems to the first 3 will be given. The students will be allowed to use models for some. For some problems they will not use models.
   Use of the perimeter and area formulas will be discussed. Use of the calculator (the squaring key, for example) will be discussed.
   Students may be asked to devise some of their own problems applying these concepts to realistic situations. (Students will work individually.)

(5) If the students have experience with fixed area, varying perimeters problems, this problem type will be further explored.

Performance Assessment:

Students will be given a problem (such as a fencing or border problem) involving fixed perimeter and maximization and/or minimization of area. The problem may involve finding an efficient way of doing something. (Prices of tile per square unit of tile may be given, for example.) Students will be asked to solve the problem, using models and various forms of analysis. Graph paper, tiles, string, rulers, etc. will be provided. Students are to give their solution mathematically, pictorial, and in a paragraph. A rubric for evaluation will be devised. Understanding of the topic (the generalizable relationships) and logical structure of the explanation will be the central concern of the rubric.

Conclusions:

I have used this activity and variations of this activity with 6th and 7th graders (and will probably use a version of it with fifth graders next year). It is an excellent problem for developing problem solving ability. Students learn to model, analyze, and represent problems in numerous ways. The problem also necessitates the search for patterns and the discovery of rules and relationships, which are vital elements of mathematics at all levels.

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Phenomenological Pizza

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Objective:

Students will draw a circle using string and a ruler.
Students will determine areas of different size circles.
Students will determine area of a sector of a circle.
Students will find how many two topping pizzas can be made using 14 toppings.
Students will determine cost per square inch.

Materials Needed:

*markers
*cardboard or posterboard
*funnel
*pizza menus
*string
*paper plate
*rulers
*6 inch circle

Strategy:

Ask what the shape of a pizza is. Hold up the six inch circle and explain that this circle is the size of a six inch personal pan pizza. Then hold up the paper plate and tell them it is nine and one half inches. Then pass out pizza menus and ask students for the sizes of pizzas indicated on the menus. After students name the different pizza sizes, ask them how these sizes are determined. They should recognize that these are the diameters of the pizza. Next, have each student using the cardboard, string, and a ruler draw a circle the size of the pizza diameters. Have them draw over the circles in marker. Bring each of the pizzas up to the board and display them. Next, find the area of each size pizza. Compare the prices to the areas and determine the price per square inch. Have students determine which size is the best buy. Next ask students how they would find the area of a slice of a pizza. Cut a piece out of the paper plate and measure the angle of the sector and then using the angle find the area of the slice of pizza. For example, 60 degrees would be one-sixth of the area of the circle. Finally, give the students the menus again and have them enumerate all the pizza toppings mentioned in the flyer. Then have them find all the two topping pizzas they can make using those toppings.

Performance Assessment:

As a performance assessment for this lesson, you could cut out several different slices of pizza and have students find the area. You could give them another menu and determine the difference in price and you could also have them construct circles of different sizes.

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An Introduction To Volume

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Objectives:

This mini teach is designed for grades 3 to 5.

L To count volume in cubic units
L To multiply to find volume
L To estimate volume
L To write a multiplication sentence to find the volume
L To discover volume of different containers
L To make a cost analysis of different brands of popping corn
L To learn the definition of volume

Materials Needed:

L Connecting cubes or base ten blocks
L Rectangular containers similar in size
L Potting soil
L Cubic rulers
L Work sheets
L Three different brands of unpopped popping corn
L Air popcorn popper
L Bowls or bags for popcorn
L Calculators

Recommended Strategy:

Activity 1-Volume Measurement

Students should work in groups of four.
Place several rectangular containers similar in size on the table. Each container should be numbered. Have one student put the containers in order of total volume. Ask the class if it is correct. Each group should write down the order they think the containers should be in. Write each group's answer on board. Divide containers among groups to measure volume. The group that wins gets the point or prize.

Each group will have one clear rectangular container. Have the students use base ten blocks to estimate the volume of their container by making a model of the container. Each group will then put their model inside the container to check their estimation. The group which comes the closest to the correct volume wins the prize.

Using these same clear containers, tell the students they will fill flower pots with soil. Give each group a rectangular flower pot or box and a ruler. They are to measure the flower pot/box to get the volume. They must write a number sentence. Write each number sentence on the board. Each group will then use soil to fill their flower pot to check measurement. The group which comes the closest to the correct volume wins. You can give them seeds to plant and observe the growth.

Activity 2-Volume Value

Have three different brands of popping corn available to the class. A large range in prices (one economy, one moderately priced and one expensive) will give the experiment more impact. Assign students to groups of three or four and ask them to design an experiment that will determine which popping corn is the best value by comparing the cost of eight ounces of unpopped corn with the volume of the popped corn. Discuss each group's method with your class. Carry out the experiments with the class. Students must show work and formulas they used. They should answer the following questions: Is there a difference in brands? If so, which brand is the best value? Why is this a better buy? Are there other factors you want to consider besides price per unit? If so, what are they?

Performance Assessment:

- L Students should use base ten blocks to design their own rectangular prism.
- L They will make a drawing of the solid figure with accurately labeled dimensions.
- L They will state volume.

Conclusion:

Students will be able to learn how to estimate volume using the phenomenological approach as well as participate in a hands on activity to calculate volume. Once skill is learned, students will be able to apply to real life situations.

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Measurement of Volume

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Objectives:

This mini teach is for middle school and high school students. It can be adapted for younger children as a demo.

Students will be able to measure the volume of a clear container. Students will be able to use a stop watch. Students will be able to estimate the volume of a container using proportions.

Materials Needed:

Clear jars, glass or plastic, enough of them so that every group of students will have two containers to measure. Enough sand to fill the largest container. Measuring bowl and cup marked in milliliters; candles and matches; stop watches for each group.

Strategy:

What was expected was a linear relationship between the burning of oxygen in the jar and volume of air that it contained. If it is linear it will be predictable. Knowing how long it takes to extinguish a candle for a certain volume you should be able to predict either the volume and or the time to extinguish a candle for another container.

The students will time how long a candle will stay lit when a jar is placed over the candle. The student will measure the volume of the jar by filling it with sand and using the measuring bowl or cup to find out how much sand is in the jar in terms of the metric system.

Students will then time how long a candle will stay lit in a much larger container. Knowing the previous data regarding volume and time and now knowing the time for this new jar the student should now be able to predict the volume of the second jar. The prediction is developed through proportions. The ratios that make up the proportion are: volume is to time as second volume is to second time. Restating the problem, the proportion will look like: **volume in ml/time to extinguish the candle = unknown volume of the new jar/time to extinguish the second candle.**

Solving the proportion the student will have the predicted volume. To verify the prediction the student will measure the volume of the second container using sand. The student will determine how close the prediction is to the actual measurement.

Performance Assessment:

The linear relationship that was expected was not produced by this procedure. It was not established that there is linear relationship. The predictions for the larger jar were off. If the time was measured for the larger jar then predicted volume was larger then the actual measured volume. If the volume of the larger container was measured then the predicted time differed greatly from the actual time.

Sources of error are pressing the stop watch (timing errors), the candle is not burning at a constant rate, a larger flame burns oxygen at a greater rate; errors using the measurement bowl; the jars need time to refill with oxygen, if you try to repeat the timing of the burning candle too soon the results will vary as much as 4 to 5 seconds.

It was a good lesson in measuring, timing and gathering data. But it did not support the hypothesis. Because the hypothesis is not supported then it creates a problem for the students. The expectation is that the goal should be achieve and it wasn't. This is a problem that will need to be addressed with the students.

Things that could be tried to improve the results are: work with larger volumes such as storage cases instead of jars; the candle be replaced with a source that burns consistently such as of oil with a wick.

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Volume and Surface Area

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Objective:

The main objective is to understand the difference between surface area and volume. This activity is appropriate for grades one through twelve.

Materials Needed:

1. Paint brushes
2. Water color paint
3. Boxes of sugar cubes (198 in each box)
4. Cup with some water
5. Cake baked in a rectangular or square pan
6. One can of frosting
7. Plastics knives
8. Plastic rulers
9. A roll of wax paper
10. Little plastics zip-lock bags

Strategy:

For the appropriate level, give students a handout with different sized drawings of rectangular prisms or cubes. Have students construct these shapes using sugar cubes. Sugar cubes are one-half inch cubes. Students then count the cubes. This is the volume. Students can practice drawings three dimensional solids made up of cubes.

Give students pictures of solids constructed of cubes that are not rectangular prisms. Discuss the cubes that are "hidden".

You can put a little Elmers glue to hold these solids together. Now paint or use a marker to color or paint all of the outside surfaces. The students count the number of squares they have painted. This is surface area.

Have students come up one at at time and cut a "cube" of cake 1x2x2 or 1x1x2. Give each student a plastic knife. Let them frost the cake so that they can experience surface area. Have them try to get it on all sides.

Performance Assessment:

Depending on the level of the students or class you can evaluate the class through oral participation or in written follow up activities.

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"An Introduction to Area and Perimeter"

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Objectives (Staff):

Demonstrate a phenomenological approach to teaching mathematics

Inspire others to use the approach

Objectives (Grades 4-7):

Form rectangles by using tiles

Measure area and perimeter by counting

Measure and record area and perimeter

Describe dimensions of rectangles

Discover and apply rules for measuring area and perimeter

Measure rectangles using transparent grids and determine area and perimeter

Observe patterns formed by rectangles with constant area or perimeter

Materials Needed:

inch grids centimeter grids scissors

worksheets with tables for recording area and perimeter

Recommended Strategy:

Cut 24 thirty-six inch tiles

Use tiles to make rectangles

Count tables (area) and number of people who can sit at the table (perimeter)

Show all rectangles on grid with area equal to 12 square cm.

Discuss dimensions

Introduce appropriate mathematical vocabulary

Order rectangles from largest to smallest perimeter

Compare shapes of rectangles with area equal to 12 square cm.

Record dimensions, area, and perimeter

Apply rules for finding area and perimeter

Measure rectangles of various sizes by using transparent inch grids

Record dimensions, area and perimeter

Show all rectangles with area equal to 24 square cm.

Record dimensions, area, and perimeter

Demonstrate pattern formed by rectangles with constant area

Show all rectangles with perimeter equal to 24 cm.

Record dimensions, area, and perimeter

Demonstrate pattern formed by rectangles with constant perimeter

Performance Assessment:

Draw representations of two gardens with the same area, but with different dimensions. Fencing materials must be purchased. Which garden will cost less money? Explain your answer.

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An Introduction to Estimation and Measurements

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Objectives:

This lesson is designed for grade levels 3-5
Upon completion of the lesson, the students should be able to:
- Convert ounces to pounds
- Measure liquids
- Describe measurements in sizes
- Measure volumes
- Understand the importance of knowing and using the measurements
- Observe shapes and sizes in measurements
- Discover and apply rules for measuring liquids

Materials:

- Several containers of various sizes and shapes (vases, bottles, bowls or cups)
- Measuring utensils (teaspoon, tablespoon, measuring cups)
- Pancake mix
- Spatula
- Hot plate
- Funnel
- Liquid (water)
- Syrup (optional)

Recommended Strategy:

- Estimate the arrangement of containers in order from least to greatest.
- Use the 1 cup measurement tool to fill each container. Count the amount of full 1 cup measurements each container will hold without any of the liquid spilling over.
- Record the amount of cups each container will hold.
- Discuss whether the original arrangement was accurate.
- Introduce the known measurements.
- Order the containers from smallest to largest (If original estimate was out of order).
- Compare estimated answer to actual answers.
- Demonstrate the use of measurements by reading directions on a pancake box.
- Compare a pancake made of mix and water being measured accurately versus one with mix and water just estimated.

Performance Assessment:

Demonstrate your use of measurements by cooking the mixture. Observe the surface of the pancakes and taste the pancakes. Discuss any differences discovered between the two types of mixes. Record the consistency of both mixes. Discuss any changes in the two pancakes after they are cooked. Enjoy the project!
This project is best used first thing in the morning.

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Circumferences, Diameters, and Radii

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Objectives:

Students will be able to measure circumferences in inches.
Students will be able to compute radii and diameters, given different circumferences.

Materials Needed:

-blackboard
-notebook paper
-signs
-tape measures
-cans

Strategy:

The strategy will incorporate cooperative learning, and direct teaching techniques. The direct teaching method explains the objectives and how to measure the circumference in inches and compute the radii and diameters. Cooperative learning encourages the students to interact to formulate the correct answers.

Direct teaching techniques: A short lecture is given on how to measure the circumference in inches and compute the radii and diameters.

Cooperative Learning: Students will form three groups. Each group will be given a tape measure and cans. Each group will try and determine which can has the largest circumference, radii and diameter. Students will compute and compare their data. Next, students will be go to five workstations to measure the circumference and compute the radius and diameter of a light pole and four different size trees.

Performance Assessment:

Students will be given twenty objects to compute their circumferences after measuring the diameters and radii.

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Measuring in Inches and Centimeters

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Objective:

To teach 6th grade students how to measure in inches and centimeters.

Materials Needed:

Paper clips, straws, yarn, 1" cubes, centimeter cubes, rulers, tagboard and scissors.

Strategy:

The students will measure common and familiar objects using both the 1" cubes and centimeter cubes.
The students will then use the 1" cubes to make a 12" ruler and the centimeter cubes to make a 31 centimeter ruler.
The students will then measure common objects using both the inch ruler and the centimeter ruler.
Students will convert from inches to centimeters and from centimeters to inches.

Performance Assessment:

Students will be assessed on how well they make their rulers.
Students will be assessed on how accurate their measurements are as compared to those made with an actual ruler.

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Estimation

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Objectives:

This lesson is designed for Kindergarten and First Grade.

Solve problems by guessing and checking.

Identify length by using informal units to estimate.

Guess the number of peas in a pod and write an addition and subtraction sentence for the number of peas in the pod.

Materials Needed:

Construction paper	Ribbon	Peas
Scissors	Bubble gum	Scrap paper
Pencils	Blocks	Gummy bears

Strategy:

Students will draw around foot on construction paper to make foot prints. Then they will cut them out. Students will measure using informal units.

Students will cut a piece of ribbon to their approximate head size. They will check by using tape measure to compare actual size and approximate size.

Guess the number of bubble gums in a jar. Check by counting.

The students will guess the number of peas in a pod and write an addition and subtraction sentence for the number of peas in a pod. Check by using counters (cubes or gummy bears).

Conclusions:

These activities can be implemented to solve problems by guessing and checking using non-standard units and standard units of measurement. This approach gives students hands on experience to solve problems.

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Measurement of Objects Using Similar Triangles in The Plane

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Objectives:

The students in the high school geometry class will apply the use of similar triangles to a sight tool in order to measure the distance between, or height of large objects such as buildings or trees.

Materials Needed:

(Dimensions used can be adjusted for own use)
1/2 inch plastic tubing cut into 2' length for sight tube
1" x 2" x 4' wood base and arm
29cm x 33cm cardboard squares
30cm string cord
Washer weight
Bolt with wing nut and locking washer
Copy of centimeter ruler
Long tape measure

Strategy:

Construction of this measuring tool involves fastening two 1" x 2" x 4' boards with bolt wing nut and locking washer placed together approximately one inch from the end of both boards. This will form the one arm and the base of the tool.

The 30cm string cord with a washer weight is attached to upper left hand corner of the 29cm x 33cm card. This card with weighted cord is attached over the head of the bolt of the measuring tool at the edge of the joined stick. A sight tube is glued onto the arm above the attached card at the top corner edge of the joined stick. This forms the top upper corner of the measuring tool. Leveling the measuring tool will set the position where the weighted cord crosses the bottom of the card in a position exactly even with the position of its attachment to the top corner of the card. This will help determine where the zero position of the copy of the centimeter ruler should be glued.

An angle of elevation will be formed by looking through the sight tube. The top of an object observed will form the local point. This is point b of the triangle. A line can be imagined across from the eye of the observer to the object observed. On this object point c can be named. The eye of the observer forms point a. A large triangle has been formed by the thought process of connecting the points from the eye of the observer, to the top of the object observed, to the eye level on the object, back to the observer.

A second triangle similar to the above triangle will be formed onto the cardboard card attached to the measuring devise. When the measuring devise is elevated the cord will move across the centimeter ruler glued at the bottom of the card. When the cord stops moving, it will provide the measurement of a side. Label this crossing, point e. Point d can be named at the top of the where the cord is attached. Point f can be named at the bottom corner of the card where the card forms a right triangle. Segment df will be the side of the card and the other side of the small triangle segment ef will be the measurement along the centimeter ruler.

In order to solve these similar triangles the observers will have to know either the height of the object to find the distance or the distance to the object to find the height. One then can set up the equality:

$$\frac{bc}{ef} = \frac{ac}{df}$$

.

Having three knowns, two on the card, and one from the triangle of the object observed, one can solve the problem.

The teacher will use this tool in a lesson to instruct students about similar triangles. The students can be taught the concept of similar triangles using a proportional growth pattern of triangles. This can be followed by instructional use of the tool. The students are then to be brought outside and begin the actual computation of similar triangles by using the measuring tool.

Performance Assessment:

The students can be evaluated in groups. Collection of group work will reveal how accurately the measurements were taken. Correct mathematics can also be checked. The scores given can then be recorded and individuals will be given a group grade.

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Travel Triangles

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Objectives:

This presentation can be adapted for intermediate and upper grades. Students will review and demonstrate an understanding of the three kinds of angles (by degrees). Triangles and related quadrilaterals will be explored and their areas found with cut-outs, rearranging parts, etc., to discover and then apply pertinent formulae. A few days to two weeks of classes will be needed.

Materials:

Students need a protractor, straight edge, compass, a few sheets of construction or plain paper, a few poster board pieces at least 8" by 10", and scissors. The teacher supplies brightly colored pre-cut triangles large enough for display, (at least one of each kind), a tailor's measuring tape, a carpenter's rule, tape to post models and student made figures on the wall or chalkboard, and a supply of construction paper to demonstrate the folding and cutting of triangles from squares and rectangles.

Strategy:

These steps may be adapted as appropriate for various groups.

1. Review acute, obtuse and right angles by having students model each with hand and arm formations. List terms with $>90^o$, $<90^o$, or equal to 90^o and label a diagram of each on the chalkboard.

2. Fold a rectangular sheet of paper in half diagonally while asking what kind of triangles are formed. Have the students do the same folding of their paper and finger-trace the right angles and then each of the other kinds of angles. Measure the angles with protractors, name and label the degrees on each, and draw and label each kind in their personal class notes. (Everything important goes into class notes.) Post the models described in "Materials" and as many student samples as practical.

3. Have the students recall how to find the area of rectangles and squares, and find the area of a sheet of paper, the end of which will then be folded up to obtain a square. Cut or tear off the excess. Next find the area of the square. Then fold it diagonally to see what kind of triangles result. Compare them to those found in step 2 after measuring and labeling their angles as well. Cut out the triangles and shift them around until a rhombus is formed. Do the same with the triangles formed inside the rectangle to form a parallelogram. Post the models for this so that students can see how and why the area of both the rectangle and parallelogram formed with the same triangles is equal, and found using the same formula, i.e., L x W = area. Find the area of the parallelogram and rhombus and compare with the rectangle and square areas.

All the above figures can be shaped with both the tailor's measuring tape and with a carpenter's rule for additional visualizing. Students can do the manipulations described above easily with these tools. Use masking tape to affix the measuring tape to a chalkboard temporarily to demonstrate with it. The carpenter's rule has the advantage of rigid segments so that it can also be used to show polygons with more and more sides up to a duodecagon, and to elicit the observation that the more sides on a polygon the more closely it approaches the circle.

4. Return to the triangles found within the rectangle and square. After having found the quadrilateral areas, ask students how the area of the triangles they found inside (step 3) can be found. (Half of the rectangle or square they are in.) Then help them express the formula: b x h divided by 2. Use this to find areas of several examples, (supplied on worksheets for additional practice). To find the area of non-right angle triangles, the altitude, or height must be given, or measured. If it is not already drawn, show students how to draw a perpendicular from the base to the apex using protractors. Extend the base on obtuse triangles. The perpendicular, i.e., altitude needed will fall outside the triangle. It is critical that students see this and practice it. Using the cut out triangles from step 3 provides the initial experience for the isosceles and scalene triangles. Be sure to cut some examples of obtuse triangles as well, for this purpose.

5. Have the students use a circle provided on a worksheet, or draw their own with a compass, at least 6 or 7 inches in diameter. Use a protractor to trisect the circumference, marking a point at each 120 degrees, then connect them with straight line segments, to produce an inscribed equilateral triangle. Post a few precut display models and student done samples. Have the students measure and label angles, sides, and find the area.

To do the mini-projects below with best results, use thick enough paperboard. Two options:

a) Have students find the midpoints of the equilateral's sides and connect them producing another triangle within. How many equilaterals result? Cut the sides of the "outer" triangles and fold the inner sides so that the interior triangle becomes the base when the vertices of the outside triangles are pulled up to form a pyramid;

b) Mark the centerpoint of a circle, then trisecting points on the circumference of a circle at least 8 inches in diameter. Draw line segments from the centerpoint to the three marked points. Cut alongside the segments from the circumference in to about half a inch from the center leaving about a quarter inch on each side of the lines, curving as one approaches the center to continue alongside the next line. Three equidistant spokes of a "wheel" about a half inch wide should result. Hold it upright by one spoke and toss. Instant boomerang!

Optional, but a favorite, is a set of portable triangles constructed with wood slats. Vertices are formed by attaching ends to each other with bolts which allow the angles to be changed, but which will retain a set position with slight tightening. For a surprise effect, attach an additional slat to one of the triangles to form a rectangle or square. Push the top over to form a parallelogram or rhombus with the same set of slats.

Performance Assessment:

All the following may be evaluated for assigning grades.

Students will make personal kits of the four kinds of triangles, cut them out, with protractor measured angles labelled, and will construct a mini-project which will work as intended only if work assigned has been correctly completed. Pre-printed centimeter grid worksheets may be used to diagram and find areas of triangles as directed. These can be used for further practice, and to assess students' comprehension of the concepts acquired and applied in the activities below, along with observations of their performance during the activities.

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Measurement-What is it?

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Objectives:

The objective of this lesson is 4 fold.
Students will learn:

1. Practical reasons for measurement,
2. The use of various tools for measurement,
3. How and why those tools might be chosen and/or designed,
4. The need for uniformity and agreement on definitions of measurement.

Materials needed:

The materials for this lesson may vary depending on what you want to measure. For the purposes of the mini-teach I made a cut out of the following.

* Shoe
* House
* Train
* Pencil

In addition you will need index cards.

Strategy:

Demonstration-(time limit 10 minutes)

The teacher asks for a volunteer from the class to be a guinea pig in an experiment.
The class is then told we are going to measure this student.
Before we can do that, we must ask four very important questions.

1. "What do we want to measure?"
2. "How shall we do it?"
3. "When will we know that we have done it?"
4. "What tools shall we use to measure with?"

The last question put to the class will be
"Why did you pick that tool?"

Hands On Experience-(time limit 15 to 20 minutes)

The class is broken up into teams. Each team consists of the following:

* Speaker (Reporter)- Reports the results of the team to the entire class.
* Recorder- Records the decisions and the results of the team and how those decisions were reached. The Recorder also records how the group interprets their instructions.
* Motivator- Encourages the team forward with positive affirmations and settles disputes among the members of the team. The Motivator also makes sure that everyone is doing their job.

* Engineer- Directs the method and use of the measuring tool based on the instructions of the Speaker. Only the Engineer may measure and handle the measuring tool.
* Inspectors- Check the work of the engineer and the recorder.

From each group, the Speaker draws from a stack of index cards what their team is to measure. From another stack of index cards, the Engineer draws the type of tool their team must use.

Each team must find the area, perimeter and/or volume of their object.

The team must agree on

* the procedure used to measure the object,
* the final result and definition of parts (i.e., lengths, widths, etc.).

Review Team results-(time limit 15 minutes)

Each teams measurements are recorded and compared to the measurements of that item in feet and inches or meters. The measurement tools are then compared to conventional measuring tools. Observations are made on the differences and similarities between the design and function of the tools.

Performance Assessment:

Students are graded on:

1. their participation in the discussions;
2. their ability to determine the area and perimeters of objects;
   a) using standard measurement tools
   b) using standard measurement language
   c) using standard units of measurement
3. their ability to apply their prior knowledge to solving measurement problems when non-standard resources are substituted for traditional tools and definitions.

Students should be able to apply the rules of measurement, using various tools and types of units of measures and know which tools and measurements are applicable for appropriate applications.

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Finding the Sum of the Exterior and Interior Angles of a Polygon

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Objectives:

To find the sum of the interior angles and the sum of the exterior angles of any polygon.
To review linear measurement to the nearest sixteenth of an inch and angle measurement to the nearest degree.
To construct a polygon and its exterior angles given the number of sides.

Materials needed:

For each group of four students the following is needed:
a yardstick or meterstick,
a large demonstration type protractor,
chalk and instruction data record sheet.

For each student the following is needed:
ruler, protractor.

Strategy:

Each group draws a large 7, 8, 9, 10, 11 or 12 sided polygon on the floor or sidewalk with unequal sides. Measure each interior angle of the polygon to the nearest degree and record the results. Measure the length of each side and record the results. Find the sum of the interior angles of the polygon and record the answer. Extend each side of the polygon forming an exterior angle at each vertex. Measure each angle to the nearest degree and record the result. Find the sum of the exterior angles of the polygon and record the result.

As a class, review the fact that the sum of the interior angles of a triangle is 180. Divide 4, 5, 6, 7, 8, 9, 10, 11, and 12 sided polygons into triangles showing the sum of the interior angles is 2x180, 3x180,..., 10x180, respectively. Generalize to the sum of the interior angles of a n sided polygon is (n-2)180. Draw a 7 sided polygon and its exterior angles and label the angles. Mark one end of the meterstick and place its center on the first vertex, slide the center along the side of the polygon to the next vertex, continue until arriving back at the starting vertex. The path of the marked end of the meter stick is a circle. Generalize to the sum of the exterior angles of a polygon is 360. Each student draws a 3, 4, 5, 6, 7, or 8 sided polygon and its exterior angles to the edge of the paper. Mark an arc on each exterior angle and cut each out. Place all of the vertices of the exteriors angles together forming a circle. Generalize to the sum of the exterior angles of a polygon is 360.

Follow the above activity with an octagonal work sheet having the students record the measure of each angle and side on the figure. Place the sum of the interior angles in the center of the octagon. Tape the octagon onto a second sheet. Draw the exterior angles of the octagon on the second sheet and record each measure on the angle. Place the sum of the exterior angles on the bottom of the second sheet.

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Forming, Measuring and Labeling Angles

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Objective:

Students will be able to form angles, measure angles and label angles.

Materials Needed:

1. protractor
2. angle patterns
3. apparatus for forming angles

Strategy:

Forming Angles

1. Provide each student with items needed (see materials needed)
2. Explain the vocabulary words: point, ray, line segment, vertex, and angles
3. Demonstrate how to form angles
4. Observeration by students

Measuring Angles

1. Explain the purpose of a protractor
2. Demonstrate how to place the protractor on the angle on the student's paper
3. Explain how to read the number scale on the protractor
4. Explain that angles are measured in degrees

Labeling Angles

1. Explain that angles are commonly labeled by using letters but they can also be labeled by using numbers
2. Explain that an angle is labeled with three letters, but it can also be labeled with one letter only or with one number only
3. Show the symbol for an angle
4. Explain which of the three letters or which of the three numbers should be placed on the vertex
5. Demonstrate how to label the angle
6. The students will practice measuring, forming and labeling angles

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What's My Area?

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Objectives:

To cover an area with uniform tiles and count the number of tiles needed.
To recognize rectangles, triangles and squares.
To review basic colors.

Materials needed:

One inch multi-color square tiles
Rectangular tiles
Triangular tiles
Worksheet with different-sized shapes

Strategy:

Each student will be given some square tiles. The students will find a space on the floor to play with their tiles. After the children have played with the tiles, tell them it is time to learn about area. Distribute papers with different-sized shapes. Tell children to cover the shapes completely with their tiles. After the shapes are covered, ask how many tiles did it take to cover the shapes. Repeat the procedure with rectangular and triangular tiles.

After the first concept has been taught you may introduce a new way of finding area. You may give the students different square patterns. Some patterns may require the students to use rectangular and triangular shapes.

As a follow-up activity, the students can make up their own worksheet with different-sized shapes. They would trade worksheets with one of their group members. The group member would use square tile, rectangular tiles and triangular tiles to cover the shapes on the worksheet.

Repeat this lesson until concept is mastered.

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Geometry and the Geoboard

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Objective(s):

The 6th grade student will be able to:

1. Discover the fun of using the geoboards as they learn many mathematical concepts.
2. Visualize the concepts of squares, rectangles, triangles and polygons.
3. Explore line segments, areas, and perimeters.
4. Demonstrate the phenomenological approach in learning geometry.
5. Understand the multicultural aspect of geometry and the geoboard.

Materials:

Geoboard
Geobands
Dot paper
Overhead projector (optional)
Activity sheets

Strategy:

Discuss with the students the origin and the various types of geoboards (square and circle). Issue the geoboards and the geobands to each student. Let the students explore different shapes on their own. Elicit from the student ways the geoboard can be used to explore different geometric shapes.
Introduce dot paper to the students. Use the overhead projector to show the relationship between the geoboard and the dot paper.
Explain the coordinates on the geoboard and let the students find points.
Show what one square unit is on the geoboard.
Give example of a line segment on the geoboard. Let the students practice making line segments, horizontally, vertically, diagonally, and shortest to the longest.

Activity 1.
Locate the circled points on your geoboard. Name them. (On the overhead projector select points to circle.)

Activity 2.
The game Tic Tac Toe is an appealing way to introduce a coordinate system for graphing. Start with a five by five array of dots on the chalkboard. The plastic geoboard for the over-head projector works well for this activity.
Ask a student to name two numbers. Ask another student to name two numbers. Mark one team's points with X's and the other teams's with O's. Three in a row wins. Teams take turns giving you pairs of numbers. If a pair is given that does not fit on the graph, that turn is lost. If a pair is called and that dot has already been marked, that turn is lost.

After playing this game a few times, change the rules so that it takes four in a row to win.

Activity 3.
Make the figures shown on the overhead projector on your geoboard. (Display and label various polygons A, B, C, etc. and let A have an area of 6 square units). Copy on dot paper.

Activity 4.
Using the activity sheets you made in Activity 3, find the areas of the polygons.
The geoboard is not needed for this activity.
Count the squares in example (a). How many do you see? The number of squares in the figure is called the area of the figure. The area of the figure in example (a) is 6. Notice we have put the 6 inside the figure. Write the correct area inside of each of the other figures.

Performance Assessment:

In the previous activity you were to make different figures on your geoboard with different areas. Now, see how many figures you can make on your geoboard, all of which have an area of **six** square units. This larger number allows much more variety. Be sure to check the area on your geoboard and sketch it. Remember, by different we mean different size and shapes. (You will need to distribute dot paper.)

Conclusions:

Geoboards enable us to count units of area of geometric figures.

References:

Meserve, Bruce E., Sobel, Max A., Dorsey, John A., **Contemporary Mathematics**, 4th. Edition, Prentice Hall, 1987.

Cech, Joseph P. and Tate, Joseph B., **Geo-board Activity Sheets**, Ideal School Supply Co. , Oak Lawn, Il. 60453, 1989.

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An Introduction to Angles

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Objectives:

The students will be able to name, classify, identify and measure angles.

Materials Needed:

1) Thin wooden sticks 10" x 1/2"
2) Protractors
3) Papers
4) Pencils

Recommended Strategy:

1) Give each student three sticks, a protractor, a paper and a pencil. Let each student put the paper on his or her desk. Then take one of the sticks and put it on the paper horizontally. Take a second stick and join it to the first stick vertically at the left endpoint. The two sticks join together to form a pattern. The two sticks represent two rays having the same endpoint. The stick put horizontally represents a ray going indefinitely to the right while the stick joined to it vertically represents a ray going upward indefinitely. The two rays with the same endpoint form an **angle**. The rays are the sides of the angle. The common endpoint is the vertex of the angle. The angle formed in this pattern is known as a **right angle**.

Protractors are used to measure angles. The units used in measuring angles are degrees, minutes and seconds. In geometry, we usually use degrees; in the above case, **the degree measure of a right angle is 90**.

2) Let the stick that is horizontal remain in the same position. Now rotate the other stick clockwise. Another pattern is formed. Let the students draw it and measure the angle formed. **The sticks form an acute angle whose measure in degrees is greater than 0 and less than 90**.

3) With the horizontal stick in the same position, rotate the second stick to the left passing through the vertical position. Let the students draw the pattern and measure the angle. **The sticks form an obtuse angle whose measure is greater than 90 and less than 180 degrees**.

4) With the horizontal stick still unmoved, rotate the second stick to the left until it is in the same straight line with the horizontal stick. Let the students draw the pattern formed and measure it. **The sticks form a straight angle whose measure is 180 degrees**.

5) Now that the two sticks are in the same straight line, let the first stick remain in its position but move the other stick further in a counter-clockwise direction towards the horizontal stick. This forms another pattern. Let the students draw and measure it. **This is a reflex angle whose measure is greater than 180 and less than 360 degrees**.

6) Join the two sticks together in a straight line. Then join the third stick to them at the endpoint where the two sticks meet. Let the students draw the pattern and measure the angles formed. **The three sticks form adjacent angles whose sum is 180 degrees**.

Conclusion:

Discuss with the students the fact that angles are a part of their daily lives. Streets and buildings are constructed using angles. Airplanes take off on angles. Installation of revolving doors involve the use of angles. The military bombers fire at angles. This experiment gives students a visual appreciation of geometric vocabulary. They can experiment at home with pieces of spaghetti. As homework, let the students classify the different angles in their classroom and environment.

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Use A Chair To Teach Math

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Objective(s):

The student will learn some basic operations of math by measuring a chair.

Materials needed:

Folding chair or desk chair, desk, tape measure, paper, graph paper and a box.

Strategy:

Place a folding chair or desk chair on top of a desk so all students can see.

Have students measure the various parts of a chair. (back, legs, seat, height, width, etc.)

All students should make a list of these measurements for their personal use later on.

After measuring the chair, ask the class for answers to questions like the following: What size box would it take to mail the chair? Could two chairs fit in the same box? How many chairs could fit in this room? What area of space does the chair occupy per floor space? These questions should also serve to motivate students to think up questions of their own.

Give each student a sheet of graph paper and pencil and ask them to plan a drawing of the chair. Then give them a second piece of graph paper and ask them to make a second drawing. This time half the size of the first one. How many chair lengths in one mile (5280ft)? Solicit additional math questions from the students. Allow time for the students to discuss problems that exist; for example: "It depends which way the chair is turned!"

Have students use the measurement to find answers to the question asked and list the operation used. Make sure the students make or find a box for the chairs to fit in for mailing.

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Measurement (cup, pt, qt, gal)

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Objective:

Fifth grade students will be able to rename measurements with cups, pints, quarts, and gallons and to choose appropriate units of capacity.

Materials needed:

Materials needed are per group.

Two 8-oz cups
Four 1-qt containers
Two 1-pt cartons
One 1-gal jug filled with water

Optional: funnel for easy pouring

Strategy:

Divide the class into small groups and provide them with a lab sheet like the one below. Have each group fill out a lab sheet.

Capacity Lab Sheet

1. Pour 4 quarts from the gallon.
 Q. How many quarts make a gallon?
 A.

2. Pour 1 quart into the pint containers.
 Q. How many pints make a quart?
 A.

3. Pour 1 pint into the cups.
 Q. How many cups make a pint?
 A.

Additional questions:

How many cups are there in 1 quart?
How many pints are there in 1 gallon?
How many cups are there in 4 pints?

*NOTE: To rename larger units with smaller units, you can multiply.

To rename smaller units with larger units, you can divide.

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Measurements In The Metric System

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Objectives:

Given teacher guidance the third grade students should be able to:
1. Estimate, then measure to the nearest inch.
2. Estimate, then measure to the nearest centimeter.

Materials:

A worksheet on unmarked rulers
Meter sticks
Scissors
Stapler
Tape measures
Items to be measured

Strategy:

This mini teach is directed toward 3rd grade students who will learn about centimeters, decimeters, and meters. They will learn a centimeter is smaller than a meter. It is used to measure small things. They will understand that another name for 100 centimeters is one meter. One decimeter is equal to ten centimeters. One meter is equal to 100 centimeters. The student will understand that each number line marks off one centimeter. The teacher will emphasize the fact that before reading a ruler, make sure that they measure from left to right. Students will use the meter stick to demonstrate that 100 centimeters equal 1 meter. The students will measure their hands, feet, the width of a desk, the height of a textbook and the length of a pencil. They will walk around the classroom to list items and estimate their length. Then the students will measure and record the exact length of each object.

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The Area of a Circle (Version 2.0)

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Objectives (Staff):

Demonstrate a phenomenological approach to teaching mathematics.

Inspire others to use the approach.

Objectives (Grade 8):

Review areas of plane figures.

Determine the relationship between the circumference and diameter of a circle.

Show the geometric representation of the area of a circle as the shape of a parallelogram.

Derive and use the formula for computing the area of a circle.

Participate in group activity.

Materials:

Tape measures
Round container lids with varying circumference measurements
Paper circles (equal circumferences)
Paper circles with varying circumference measurements
Centimeter grids

Transparencies:

Table with 4 columns labeled - lid number, circumference, diameter, and circumference/diameter

Graph: Label x-axis as diameter and y-axis as circumference

Several blank transparencies

Worksheet:

Draw four circles of unequal radii on a cm. grid

Recommended Strategy:

Form small groups and measure circumference and diameter of several lids.

Divide circumference by diameter for each lid.

Record data on table (transparency).

Graph ordered pairs (diameter, circumference).

Discuss constant (pi) that results when circumference is divided by diameter.

Cut paper circles with equal circumferences into 16 equal pie-shaped pieces.

Arrange 16 pieces (on cm. grid) to form a parallelogram.

Calculate area of parallelogram.

Label base of parallelogram as 1/2c and height as r.

Review c = (pi)d   c = 2(pi)r.

Show that area of the parallelogram is 1/2(2pi*r)r or pir^2.

Use A = pi*r^2 to calculate area of whole circle.

Compare area of parallelogram to formula calculations.

Use A = pi*r^2 to calculate areas of 4 circles (worksheet).

Cut circles into 1/16's and form parallelograms.

Calculate areas and compare to formula calculations.

Extension:

Make a cylinder and show how the surface area is the total areas of two circles (the ends) and one rectangle (the side).

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"The Surface Area of a Cylinder" (Version 2.0)

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Introductory Comments:

This is a description of a phenomenological approach presentation. It is an extension of a mini-teach, "The Area of a Circle" (1986) and a PA, "The Surface Area of a Cylinder" (1988). A problem-solving situation, which requires the use of the two concepts, was formulated.

Objectives:

1) Use a phenomenological approach to problem-solving.
2) Apply concepts to problem-solving situation.
3) Participate in group activity.

Materials:

Measuring tapes
Tape (masking or scotch)
Round container lids (different circumferences)
Paper circles (equal circumferences)
Construction paper
Rectangles with different dimensions (measure of base should be equal to measure of circumference of a corresponding lid)

Worksheet:
Cut two circles with equal diameters and one rectangle from cm. grid paper. Measure of base of rectangle should correspond to measure of circumference of one circle. These figures should be used to make a worksheet which can be distributed to each student.

Recommended Strategy:

Form small groups and measure circumference and diameter of several lids.

Divide circumference by diameter for each lid.

Discuss constant (pi) that results when circumference is divided by diameter.

Use paper circles to show A = pi(r^2). (This procedure is explained in SMILE, 1986.)

Calculate areas of figures on worksheet.

Cut figures and make a cylinder.

Relate areas of plane figures to surface area of resulting cylinder.

Use rectangles and lids to make several other cylinders.

Calculate the surface areas of the cylinders (Use area of each rectangle plus two times area of corresponding lid).

Discuss related equations:

Area of rectangle section of cylinder = base * height
or
circumference of lid * height

Circumference = pi(d)
= 2(pi)r

Diameter = 2r

Diameter = c/pi

Develop formula for surface area of cylinder:

$$\text{Area} = (2(\pi)r^2) + (2(\pi)rh)$$

Review use of 2 as a constant in equation:

2(pi)r^2 (two represents two circles)
2(pi)rh (two represents two radii or one diameter)

Solve problem:

Two rectangular sheets 20 cm. by 24 cm. and 15 cm. by 30 cm. are to be rolled to form cylinders. What is the height and diameter of the cylinder with maximum surface area that can be formed using either of these sheets?

Construct the cylinder with maximum surface area (with lids).

Report results to class.

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SIMILARITY

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OBJECTIVES

Discover the factor of proportionality in similar polygons and to relate this factor to the perimeters and areas of similar polygons.

APPARATUS NEEDED

Overhead projector, rulers for each student, protractors for each student, handouts of printed polygons (these are to be measured by each student).

RECOMMENDED STRATEGY

Students will measure each side and each angle of the polygons on the handouts. They will compare their measurements with the overhead projection of these polygons and derive a factor of proportionality between each corresponding pair of sides and angles of the two figures being compared. They will measure the angles of their polygons and compare these measurements with the corresponding angles of the projected similar polygon. (Discovery: the angles retain their same measure in both figures-theirs and the overhead's).

This process can be used with different pairs of polygons to establish a factor of proportionality in their perimeters and areas. Students should discover that this factor remains constant in similar polygons and is squared when determining areas of similar polygons.

Example:Ratio of two similar polygons' corresponding sides is 1/3.

```
   Perimeters of each polygon are: 2,4,2,4 = 2+4+2+4 = 12 units
                                       3(2+4+2+4) = 36 units

 Areas of each polygon are: length x width = area in square units
                                 2 x 4     = 8 square units
                               3(2)x 3(4)  = 72 square units
```

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POLYGONS MADE TO ORDER

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OBJECTIVES

1. To construct a regular polygon inscribed in a circle by using isosceles triangles with vertex angles at the center of the circle and legs as radii.

2. To determine the values of the vertex angles (central angles), the values of the base angles, the values of the inscribed angles, and the sum of the angles of any regular polygon.

3. To allow the students to discover that as the number of sides of a polygon increases, the polygon appears to look like a circle.

EQUIPMENT AND MATERIAL

1. Compass
2. Protractor
3. Straight edge
4. Worksheets
5. Overhead Projector and projector pens
6. Colored transparencies with regular polygons

RECOMMENDED STRATEGY

A. Review the concepts of triangles and circles.
   1. Isosceles triangle
   2. Base angles and vertex angle
   3. Circle
   4. Radius
   5. Chord

B. Draw the circle.

C. Construct an equilateral triangle inscribed in a circle.
Find the value of a vertex angle by dividing 360 by 3. Draw a radius and construct the vertex angle using the value. Construct the remaining two congruent angles using radii as sides. Connect the chords. (three isosceles triangles are constructed.) Place the value of the central angle on worksheet 1.

D. Calculate the values of the base angles.
Find the values of the base angle by subtracting the value of the measure of the central angle from 180, then divide that value by 2. Place the value on worksheet 2.

E. Increase the number of sides in a regular polygon.
Construct a square inscribed in a circle. Use four radii by constructing four congruent central angles. (360/4) Draw the chords (bases) formed by the isosceles triangles. Place the value of the new central angle on worksheet 1. Place the value

of the new base angle on worksheet 2.

F. Continue to increase the number of sides (5,6,7,8,...12,...) in the regular polygon.

Find the value of each new central angle and notice the decrease. Find the value of the new base angles and notice the increase.

G. Find the sum of the base angles of any regular polygon.

Use the number of isosceles triangles constructed inside the circle. Find the sum of the base angles.(worksheet 2) Multiply that number by the number of sides of the polygon. Place the new value in worksheet 3.

Students can easily learn to understand what a regular polygon is. They will begin to notice the values of the angles; i.e., the decrease in the central angles and the increase of the inscribed angles. Students will start to question what is the largest regular polygon.

Worksheet 1: The values of the central angles for each different polygon
Worksheet 2: The values of the base angles in each set of isosceles triangles
Worksheet 3: The sum of the measures of the angles in any regular polygon

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PROPERTIES OF QUADRILATERALS

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OBJECTIVES

1. Students will discover the names and definitions of different kinds of quadrilaterals.
2. Students will discover the properties of quadrilaterals.
3. Students will learn to apply the correct property to each different kind of quadrilateral.

EQUIPMENT AND MATERIALS NEEDED

Overhead Projector, transparencies, and projector pens; Rulers; Protractors; Colored acetate plastic models of quadrilaterals for overhead; Colored plastic models of quadrilaterals for placement on wall chart; Tape for hanging chart; Large wall or blackboard chart with list of all properties of quadrilaterals; and Material to tack models on wall chart.

RECOMMENDED STRATEGY

Using the overhead projector, place quadrilaterals on the acetate until the students have discovered the names of all the different kinds of quadrilaterals.

Do a review of vocabulary to be sure that all words in the properties are understood, and at the same time develop the definitions of the quadrilaterals.

Develop a list of the facts that are true about some or all of the different quadrilaterals. These facts or properties are displayed on a wall chart that is hung on the blackboard.

Then the class is grouped into teams, and each team will be given a set of plastic models of quadrilaterals. The teams are to discuss and measure until they discover the properties that belong to their quadrilaterals. Students will be given a printout with the list of all the properties. After a period of time, one member of each team will go to the chart and place the models on a property that they possess. NO MORE THAN ONE KIND OF QUADRILATERAL ON EACH PROPERTY!

When finished the team representative should report to the teacher. When all the teams have completed the placement, an acetate with the answers will be placed on the overhead screen, and the accuracy of answers will be checked. The team that completed first and has the highest accuracy is the winner.

For homework, the students will have to complete a sheet listing all the properties that belong to each different kind of quadrilateral.

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Singleton, Earl M. III Daniel Hale Williamss851 W. 53rd Pl.Chicago, IL 6060_91-312-285-77600 **Objectives** 1) Students will be able to identify the names of angles formed when parallel lines are intersected by a transversal. 2) Students will be able to identify the measurement of angles formed when parallel lines are intersected by a transversal. **Equipment and Materials** Overhead Projectorr One plastic overlayy Three transparenciess **Materials**: Crayonss Four page worksheett **Recommended Strategies** Pass out the four page worksheet which contains the vocabulary and three other pages with parallel lines intersected by a transversal. Begin the lesson by showing the parallel lines on the overhead projector. "What are these lines?" "What are other examples of parallel lines in this room?" Have a student define parallel lines. Next, show the illustration of the parallel lines intersected by a transversal on the overhead projector. "What is created when a transversal intersects the parallel line?" -- angles. Have the class turn to the second sheet and identify adjacent, supplementary, and straight angles -- all of which equal 180 degrees. Have them color code the straight angle green and place a green arch over the straight angle to illustrate a semicircle. Call on two students to come up. Position them side by side, and ask the class the following question: What would you call neighbors who, lived right next to each other on the same side of the street? They would be next door neighbors and in math we call them adjacent angles. They share a common ray and vertex. Next, have the class turn to the third page of the worksheet and label the top of the page corresponding angles. Begin to identify congruent corresponding angles and color code each pair of corresponding angles a different color. They will have four different pairs of corresponding angles -- each pair having a different color. Proceed to the fourth page and have the class label this page alternate exterior and alternate interior angles. Again, have them color code each pair of angles. Solicit the definition of interior and exterior. Place a group of students in a circle and put one person in the middle of the circle. The teacher should stand outside of the circle. Ask questions about the relationship of the teacher to the person on the inside of the circle. This activity will help reinforce the concept of interior/exterior relationship. In order to further develop the concept of alternate, have the person on the inside of the circle alternate jumping up and down with the teacher. Go to the board to illustrate alternate exterior and interior angles. Lead them to discover that they are alternate exterior angles because they are on the opposite side of the transversal and on the outside of the parallel lines. Continue by demonstrating that alternate interior angles are on the inside of the parallel lines and on alternate sides of the transversal. After reviewing all the terms, assign a measurement to one of the angles and have the class determine the measurement of the other angles and justify their answer.

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The Surface Area of a Cylinder

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Introductory Comments:

This is a description of a phenomenological approach presentation. It is an extension of a mini-teach, "The Area of a Circle", presented in the Summer of 1986.

Objectives:

A. To relate the areas of one rectangle and two circles to the total surface area of a cylinder.
B. To relate the circumference of a circle to the base of the rectangular section of a cylinder.
C. To review the area of a circle.

Apparatus Needed:

A. Round container lids with varying circumferences
B. Rectangles, cut from flexible material, with bases corresponding to the circumferences of the lids. Allow one inch for overlapping the ends. Mark this one inch space.
C. Circles cut to match the sizes of the lids.
D. Measuring instruments.
E. Tape

Recommended Strategy:

This lesson has been designed for groups. The format of the group report should include a topic, figures (labeled appropriately), procedure and conclusions. Materials should be distributed only when needed. The recommended order of activities is listed below.

A. Review concepts from "The Area of a Circle"
   1. circumference
   2. diameter
   3. c/d = pi   c = pi*d
   4. pi is approximately 3.14 or 22/7
   5. c = 2pi*r

B. Calculate the area of the rectangle
   1. Label base, height
   2. Measure and compute area using A = bh

C. Make circular form
   1. Overlap the ends of the rectangle and tape them together
   2. Place the form on the corresponding lid
   3. Discuss the apparent shape

D. Relate the base of the rectangle to the circumference of the lid

E. Place second circle on top of the form and discuss results

F. Remove second circle and tape

G. Label base as circumference

H. Calculate area of rectangle using C = pi*d for the base of the rectangle

I. Compare the results of the two computations of the area of the rectangle

J. Calculate the area of two circles

K. Add the area of the two circles to the area of the rectangle

L. Write group report

This series of activities has been designed to guide students to an understanding of the components of the cylinder surface area formula. As students proceed with the construction of the cylinder, they should relate its form to the flat surfaces of a rectangle and two circles. The area of the two circles can be computed by multiplying pi times radius squared and that quantity times 2. In the surface area formula the process appears as $2pi*r^2$. The use of the lid and a second circle which is the same size as the lid should be related to the use of the constant 2 in this part of the formula. The different processes for computing the area of the rectangle should be related to 2pi*r*h. Discussion of the constant 2 in this part of the formula may be made at the time c = pi*d is used to compute the area of the rectangle. It is necessary for students to relate 2 radii to one diameter.

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Soap Film Models

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Objectives:

1. Encourage students to conjecture
2. Introduce concept of minimum path and minimum surface area
3. Practice measurement of line segments and angles

Apparatus Needed:

1. Four inch square plastic models
2. Polygon models
3. Soap bubble liquid
4. Overhead projector
5. Clear shallow container to hold models on overhead
6. Rulers
7. Protractors
8. Worksheets with configurations of points like the plastic models

Recommended Strategy:

1. Have students draw line segments on the worksheets, to indicate their estimate of the shortest path joining the points in the configuration
2. Dip models into soap liquid
3. Show results on overhead projector
4. Encourage students to estimate and to discover patterns
5. Measure segments and angles drawn on worksheets and compare estimates to experimental results
6. Summarize

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Primary Geometry

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Objectives:

The children will name, identify and categorize the geometric shapes (triangle, square and rectangle) by the number and length of the sides.

The students will identify triangles, squares and rectangles in their environment.

Through observation, comparison and manipulation the children will construct pictures, shapes and patterns with the triangle and square.

Using game formats the students will gain practice in recognizing and naming geometric shapes.

Apparatus needed:

1. various sized plexiglas triangles, squares and rectangles with magnetic tape applied to the backs of the shapes so they will stick to the blackboard
2. 20 triangles and squares made of plexiglas or paper (2" on a side)
3. a ditto of triangles and squares for each child (2" on a side)
4. glue
5. scissors
6. overhead projector
7. "Color and Shape Bingo" by Trend Co.
8. 1 deck "I have ....who has...." cards

Recommended strategy:

This presentation is appropriate for use with primary children. Using the plexiglas shapes the students will discuss similarities and differences as well as various ways in which the objects could be categorized. Elicit from the children that a triangle has 3 sides, a square has 4 equal sides and a rectangle has 2 long sides and 2 short sides. On the blackboard make a category heading for each shape and have several students go to the board and place the magnetic shapes under the correct heading. Review names and characteristics of each shape.

Why did you place that object there?
What are the characteristics of that shape?
What is your shape called?

Ask the children to name these geometric shapes as they identify them in the classroom and their environment.

The children will cut out squares and triangles from ditto sheets in several different colors. All of the new shapes and patterns that will be constructed will be shown on the overhead projector. This will help the child who has difficulty seeing patterns or because of poor eye-hand coordination. Shapes must not overlap or cover other shapes. They must line up evenly. Ask the students to show that: squares can make bigger squares, squares can make rectangles, triangles can make bigger triangles, triangles can make hexagons but our triangles cannot make squares or rectangles (we didn't have right angles). Allow the students to experiment with color and shape in making new figures, shapes and patterns. Demonstrate some of the creations on the overhead. After the class has had adequate time to experiment, request that they glue their "favorite" on to a piece of manila paper.

Play Trend Co.'s "Color and Shape Bingo" or make a bingo game. The "I have ... who has ..." card game is teacher made. It consists of a deck of cards, one for each student. The cards may be used to drill many topics. For example, the child reads his card, "I have a red square, who has a blue rectangle." The child who has the blue rectangle then reads his card, etc. The last card read is the winner.

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Proving Pi

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Objectives:
To show the ratio of pi by revolving a circle one complete time.
The students will learn why the ratio is true.
To allow the students to do the same independent of the teacher's help.

Apparatus needed:
You need: Two random size pieces of plexiglass.
One screw (long enough to pass through all thickness of the pieces you use)
One pair of nuts to hold the screw in place.
One aluminum channel no longer than four feet.

Recommended Strategy:
To make the circle, cut either piece first. Draw a circle on the paper covering of the plexiglass or cut random tangents to a squared piece until it is it is somewhat round. Drill a hole at the center of the piece large enough to put your screw through. Finding the center should not be a problem. Once the "round" piece is ready, sand out the rough spots. Find a thick piece of wood that you can nail the circle to . After nailing the circle to the wood, go to the sander and rotate the plexiglass until the rough spots are gone. Draw an arrow from the center to the edge of the circle (a radius). The second piece will be used for the handle and the spacers. Cut three pieces, two of the same length and long enough to extend from the center of the circle to the outside and the other about one inch shorter. The first two pieces should be wide enough to fit comfortably in your hand as they will be used to guide the circle through the channel. The third piece will be used for spacers. Drill the same size hole near the end of the two pieces to be used for the handle and two holes four inches apart in the piece to be used for spacers. **Do not cut before the holes are drilled**. At this point get help from the shop manager to assist in putting the final product together. If it is not obvious, the spacers should be cut to fit one under each handle and flush against the circle to reduce friction when rotating. Use other scrap pieces to space the edge of the handle that will be held in your hand. Sand all edges. Use the glue to hold the spacers in place at the edge of the handle. For the classroom demo, the aluminum channel will be placed on the desk or table. Stand the circle on its side, arrow down and perpendicular to the channel. Mark the origin with a pencil on the channel. Make a complete rotation of

the circle. At the end of this rotation, mark the channel again. To find this length, do either of two things. Lay the circle on the channel end over end from the origin to the end of the length at which time the measure is obvious. Or lay the circle between perpendiculars for as many times as it takes to cover this length. In either case, the measure should be 3.14159... or a number very close to that.

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THE SOLAR SYSTEM

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Objectives:

Make use of concentric circles and angles (in excess of 180 degrees) to construct a sketch of the naked-eye-visible planets of the Solar System. (What this amounts to is polar coordinates, but I do not mention it.)

Materials:

Graph paper, compass, protractor, and table of astronomical data: heliocentric longitude, in counter-clockwise degrees, and the semi-major axis (radius, for practical purposes) of the orbit, in astronomical units, for the planets Venus, Mars, Earth, Jupiter and Saturn.

Strategies:

Draw concentric circles on the board--one for each planet's radius (semi-major axis). Plot the position of each planet on its respective circle. Explain how the figure indicates if, where and when a given planet will be visible on the date in question.

A FEW NOTES:

The source for the heliocentric coordinates is the current issue of **Astronomy Magazine**--July 86--for all but the planet earth. (How strange!) To get this terrestrial data I phoned the Adler Planetarium. It is necessary to interpolate between dates to find the coordinate for Mars.

The source for the lengths of the semi-major axes (radii) of the orbits of the planets is an old astronomy book from college, but any almanac or general-information-type book should suffice.

Using standard, generic, drug-store, (quarter inch per side of a square) graph paper, a scale of two units per astronomical unit is good. The Sun is placed 16 units over and 7 units down from the upper left corner: the longer edge is horizontal. (It just so happens that for the date in question most of the planets lie in the bottom half of the concentric circle system. This means that only halves of the big circles--Saturn and Jupiter--have to be drawn--the bottom halves. This allows for a larger scale for the whole sketch. All of the circles for Venus, Earth and Mars can and should be drawn.) A ray is drawn due East, (to the right, parallel to the long edge of the graph paper), from the Sun, to serve as both a distance scale and an angle reference. The direction of the ray is zero degrees of heliocentric longitude. (Technically it points towards the Vernal Equinox.) Each planet's position is found by moving counter clockwise about the proper circle from this reference ray.

Explaining visibility is beyond the scope of a one page write-up of this mini-teach. With some thought, it should become obvious to anyone but the most casual observer.

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How Many Regular Polyhedrons Are There In This or Any Universe?

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Background

The idea of "regularity" is a very old one in geometry. It dates back to the ancient Greek mathematicians/philosophers. (See, for example, Plato's theory of "ideals"). Regular polygons are thus convex polygons whose vertex angles are all equal (or congruent) and whose sides are likewise all congruent.

The first geometry textbook, Euclid's Elements, assumed convexity without mention of that concept. We shall take convexity in its intuitive sense. Convex polygons have a very neat property: Take any vertex and draw all possible diagonals within the polygon. This process subdivides the polygon of n sides into n-2 non-overlapping triangles. Since a triangle's three vertex angles have a sum of 180 degrees, an n-sided convex polygon's n vertices must have an angle sum of 180(n-2) degrees. Now, if our n-sided polygon is also regular, each of its n congruent vertex angles must have a measure of one-nth of this angle sum.

Expressing this fact for several regular polygons we obtain the following data:

Number of Sides	Degree measure of any vertex angle
3	60 degrees
4	90
5	108
6	120

Note that as the number of sides increases, the degree measure of a vertex angle does likewise. (Thought experiment for the thoughtful reader: The exterior angles of a convex polygon become smaller as the number of sides increases, but what do you suppose happens to the sum of all the exterior angles of a convex polygon, regular or not? Can you prove or disprove your hunch? Try it!)

Regular Polyhedrons

A polyhedron is a "solid" three-dimensional figure analogous to the two-dimensional polygon discussed above. Polyhedrons have vertices, edges, and faces which to Euclid had dimensions of zero, one, and two respectively. If a polyhedron has faces which are regular and congruent polygons -- all of them -- and if at each vertex exactly the same number of faces meet, then we have a"regular" polyhedron. The question is, "exactly how many such 'critters' are there?" Obviously the number is infinite if size is considered, so we shall eliminate that consideration and ask merely how many "truly" different regular polyhedrons can exist.

More nomenclature is needed (Sorry). In two-dimensional plane geometry, angles are just angles, but in three dimensions life gets more complicated: When two planes intersect, they intersect in a line. Pick any point on such a line of intersection (edge) and in each plane construct a line perpendicular to the line of intersection. The angle between these two perpendiculars is the "DIHEDRAL ANGLE" of the two intersecting planes. In regular polyhedrons these dihedral angles are all equal (congruent). Computation of their measure can get quite

2
complicated, but isn't essential for this project.

At each vertex (point or corner) of our polyhedron there is a solid or TRIHEDRAL angle. How such angles are measured -- if indeed that concept even applies -- isn't known to this writer. What is clear is that a trihedral angle must be the meeting point of three or more planes --faces -- of the polyhedron. And recall that all faces are congruent polygons having congruent vertex angles according to the above-mentioned table and formula.

Let us examine how trihedral angles can be made: Assemble three or more polygons so that they meet along common sides with one common vertex. If the sum of the vertex angles is less than 360 degrees, then there is a gap between the outer, unmatched edges. Closing up that gap by joining the two unmatched edges yields a trihedral angle. Working with regular polygons makes our job of analysis possible.... We will start with the simplest regular polygon, the equilateral triangle, manufacture all possible trihedral angles from just that unit, and then move up as far as needed to the point where the angle sum equals or exceeds 360 degrees.

This last statement is the key to the proof (solution or answer to the initial question). If the angle sum equals 360, then there will be no gap to be closed. In such a situation, the trihedral angle degenerates to a plane instead of a "bulge", and a polyhedron can't exist. Should more regular polygons be added to the assembly, they will OVERLAP, and such a "creature" would have a negative gap. It CERTAINLY can't be folded to produce a trihedral angle.

Three, four, or five equilateral triangles can thus fit around a trihedral angle. These are the vertices of the regular tetrahedron, octahedron, or icosahedron respectively. We may be certain that no other regular polyhedra can exist having equilateral triangles for faces.

Next, move up to the regular quadrilateral -- the square. At least three squares must comprise this trihedral angle; and that is all for the square because if a fourth square is added to the assembly, the angle sum is exactly 360 degrees. The only regular polyhedron having squares as faces is the best-known, the cube. The count is now four regular polyhedra; onward....

The regular pentagon has five sides, and each vertex angle has measure of 108 degrees. Three regular pentagons attached as before yield 324 degrees and a gap of only 36 degrees. When this small gap is closed we obtain a vertex (trihedral) angle of the last possible regular polyhedron, the celebrated regular dodecahedron of twelve faces.

Our task is now over because one must next try to construct trihedral angles out of regular hexagons, regular heptagons, and regular polygons of greater numbers of sides (each with a correspondingly greater vertex angle measure). Three regular hexagons have a vertex angle sum of exactly 360 degrees, and they won't fold into a trihedral angle because there is no gap. The angle sum of three vertex angles of a regular heptahedron is greater than 360 degrees. three vertex angles of a regular heptahedron is greater than 360 degrees, so nomertex angles of a regular heptahedron is greater than 360 degrees. more regular polygons need be examined.

To sum up, there are only five possible regular polyhedra. Period.

This ended the matter for the ancients. Until about two hundred years ago that is. Then it was noticed that no one had ever explicitly called for CONVEX

polyhedra. Johannes Kepler and later Poinsot found it possible to add to the roster of regular polyhedra by creation of "dimpled" and/or stellated regular
3
polyhedra. The additional regular polyhedra won't be discussed in this report, but information about them may be found in the Bibliography.

Here is a summary of the five convex regular polyhedra:

Reg. Polyhedron	Number of Faces	Number of Vertices	Number of Edges
Tetrahedron	4 T's*	4	6
Cube	6 S's*	8	12
Octahedron	8 T's	6	12
Dodecahedron	12 P's*	20	30
Icosahedron	20 T's	12	30

*: T = Equilateral triangle; S = Square; P = Regular Pentagon

Notice two things about this table: First, in every case the numbers of faces, vertices and edges satisfy the Euler formula, F + V = E + 2.(Look up a proof of this sometime). Secondly, from the spacing of the table note that the numbers of faces and vertices interchange between Cube and Octahedron and between Dodecahedron and Icosahedron. Such relationships lead to study of the topic of "duality," basic to advanced Euclidean geometry and also virtually the foundation of "projective geometry" (an advanced extension of geometry).

If wire models having transparent faces are made of each of these polyhedra, of appropriate "size," then each of the pair of duals will so fit inside of each other that a vertex of one will lie at the center of a face of the other of the dual pair.

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(end of bibliography section. what follows was once typed onto the disk, i thought, but doesn't seem to be here, now that i want it...... ##&$)^^^^12345678) SO I WASTED TIME RETYPING THE GOD DAMNED STUFF!

OBJECTIVES

To demonstrate a simple to prove but surprising fact of elementary geometry.

To illustrate one method of mathematical (logical) proof -- Cauchy's celebrated method of cases in which all possibilities are studied one-by-one.

To create a climate in which student, teacher or both can extend their knowledge by framing additional conjectures (plausible hypotheses) worthy of investigation.

MATERIALS

Tag board, cutting instrument (scissors, "Xacto" knife or single-edge razor
4
blade), and paste or (preferred) "Scotch" brand "Magic Transparent Tape."

Models of completed polyhedra, each relevant trihedral angle, and student sets of the latter to be folded, handled, and examined.

STRATEGIES

For the basic theorem ("How Many...?"), employ the Cauchy method of cases to illustrate the virtue of patience. Hands-on work completes the proof almost faultlessly, very convincingly, and (surprise!) theoretically correct.

Class brainstorming ought to then produce a host of additional conjectures in the realm of efficient coloring of faces, dualism, wire models, best approximation of a sphere, measurement of dihedral angles, computation of the measures of such angles, the "Euler formula" and its spookiness, etc.

Finally, even highly competitive, high achievers soon see the virtue of cooperation in the manufacture of their own models of trihedral angles, entire polyhedra, stellations, and coloring schemes. The smarter the student, the quicker the realization that mass production saves time and labor.

121121112111121111121111112111111121111111121111111112111111111121111111111
12.......
(The above irrational thought ends this exercise in futility. I tried hard to shift the last three sections to the beginning of the paper but inexperience, lack of time to undo what looked like fatal errors made that impossible.......).

..
...
.... Larry Freeman 10:37 AM, July 30, 1986.

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THE AREA OF A CIRCLE

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OBJECTIVE:

To see the relationship between circumference and diameter and how that relationship, called pi, is used in the formula for the area of a circle.

MATERIALS:

A. Round container lids with varying circumferences
B. Metric tape measures
C. One graph for wall (label horizontal axis as DIAMETER and vertical axis as CIRCUMFERENCE)
D. One chart with four columns for wall (label CIRCUMFERENCE, DIAMETER, C/D, and Lid #)
E. Graphics
   1. Small square inscribed in a circle inscribed in a larger square
   2. Small hexagon inscribed in a circle inscribed in a larger hexagon
   3. Circle cut into 16 equal pie-shaped pieces and arranged to form a parallelogram

STRATEGIES:

A. Assign group activities
   1. Make a chart, on paper, similar to the wall chart.
   2. Measure C and D to nearest mm.
   3. Calculate C/D and record information on group chart.
   4. Plot points on large wall graph.
   5. Record information on large wall chart.
   6. Calculate group average for C/D.
B. Discuss results on graph. Points appear to lie on a straight line.
C. Establish C/D = pi and C = pi(D)
D. Review other area formulas:
   1. Area of square = s**2
   2. Area of rectangle = bh
   3. Area of parallelogram = bh
   4. Area of triangle = 1/2 (bh)
E. Compare apparent area of small square inscribed in a circle with apparent area of larger square circumscribed about circle with apparent area of circle:
   Area of sm. sq. (2*r**2) < Area of circle < Area of lge. sq. (4*r**2)
F. Compare areas of small and large hexagons, one inscribed in the circle, the other circumscribed about the circle. Relate to apparent area of circle. Discuss how an increase in the number of sides of the inscribed and circumscribed figures approaches the shape and area of the circle.
G. Show how the area of the parallelogram, made from 16 pieces of the circle is equal to pi(r**2):

```
A = bh
  = 1/2 (C) (r)
  = 1/2 (pi*2r) (r)
  = pi (r) (r)
  = pi (r**2)
```

H. Discuss values on wall chart. Calculate average. Compare average with actual value of pi.

I. Calculate area of circle using pi formula. Relate to figures in graphics.

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Barbara P. Lorde - Crispus Attucks Academy

M&M MATH

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Objective(s):

This lesson is designed to introduce math at the kindergarten level. All students should be able to:

1. Learn basic colors
2. Sort according to colors
3. Count 1 through 10

Materials Needed:

For a class of thirty students you will need the following:

30 small bags of M&MS
30 coffee filters
30 papers with colors red, blue, orange, brown, yellow, and green written in squares.

Strategy:

Have students guess how many M&M'S are in the bag.
Open bag of candy and put candy into coffee filter.
Sort all M&M's into sets by colors using the color sheet.
Name each color and count each set.
Once activity is finish have students put M&M's back into their coffee filters.
Ask students to put two M&M in their mouth.
Have students count how many are left.
Eat two more. How many M&M'S do you have left?

Performance Assessment:

Each student will be orally assessed on colors, sorting, and counting 1-10.

Conclusions:

The students should be able to name various colors.
Sort according to colors and count 1-10.

References:

Primary Bears, Book 1- 1987 AIMS Education Foundation

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Using Symmetry to Create A Community Quilt

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Objectives:

This mini-teach is designed for **4th grade through 12th grade** with appropriate modification for the upper grades. Students will learn about line symmetry and reflectional symmetry. Students will also utilize this knowledge by working cooperatively to make a community quilt. Students will make a quilt with four lines of symmetry.

Materials Needed:

Give one set to each group

1. Quilt patch (3 x 3 - nine 2" squares plus a one-half inch border) Activity Sheet 22
2. Hole puncher
3. Yarn
4. Crayons
5. Scissors
6. Quilt-Pattern Shapes (Activity Sheet 25) (This sheet includes several different size of triangles, squares, rectangles, and other shapes that students can cut out and trace onto their quilt patch)

Strategy:

Symmetry can be seen all around you. Symmetry exists when an object or figure can be divided along a line (line of symmetry) and each resulting image (on each side of the line of symmetry) coincides or is reflective.

1. Give each student a sheet of paper. Student should fold paper in half and cut out a valentine. Open the valentine and draw a line on the fold. This is your line of symmetry.

2. Use different figures to practice vertical, horizontal, and diagonal symmetry.

3. The quilt your class will make will have 16 patches. Each patch is composed of 9 squares (3 by 3 square). The entire quilt will have four lines of symmetry. (You may decide to have one or two lines of symmetry depending on your class.)

4. Students will work in groups to color the patches. When each group has finished, holes should be punched on each side of the quilt patch. Yarn should be used to weave in and out of the holes to connect the patches in a 4 by 4 design.

5. Use strips of crepe paper to create a ruffle around your quilt. Pleat the paper and glue or staple it around the border.

Performance Assessment:

The expected results is that the quilt will be symmetrical according to your directions. For younger students, you may want them to have one or two lines of symmetry. Students should be able to show the line(s) of symmetry and explain why their patch is symmetrical.

Reference:

Everyday Mathematics Journal II, **Everyday Learning Corporation, 1995, Activity** Sheet 22 and Activity Sheet 25.

This is a rough sample for the 16 patch quilt. Remember that each quilt patch has 9 squares.

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

In order for this quilt to be symmetric about a vertical axis, the following quilt pairs must be reflective: (1,4), (5,8), (9,12), (13,16), (2,3), (6,7), (10,11), (14,15)

In order for this quilt to be symmetric about a horizontal axis the following quilt pairs must be reflective: (1,13), (2,14), (3,15), (4,16), (5,9), (6,10), (7,11), (8,12)

In order for this quilt to have **4 lines of symmetry**, the following quilt sets must be reflective: (1,4,13,16), (2,3,5,8,9,12,14,15), (6,7,10,11).

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Sorting and Analyzing

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Objectives:

1. After the lesson the students will be able to sort, compare and analyze. This lesson can be appropriate for all levels.

2. The students will explore, observe and examine concrete objects while sorting, comparing and analyzing.

3. The students will be able to recognize a bar graph.

Materials Needed:

1. Each student will receive a sheet with a month on it and 8 cakes drawn on it; a paint brush; red, yellow and blue paint.
2. Each student will receive 2 Post-it-Notes, crayons, sorting sheets, and a questions and answer sheet.
3. Each group of 4 students will receive one 2.07 oz. package of Starburst candy and one 16 oz. bag of Starburst candy.
4. The students will receive tape, a cup of water per group of 4 students and paper towels.

Strategy:

The students will answer the question "How can we find out how many student's birthdays in each month?" The students will offer suggestions as to how to solve this problem. The students will decorate their sheet with the month and the cakes on them. They will use the primary colors and mix them to create different colors. They will get a piece of tape and tape each month in order on the bulletin board. Each student will then write their name on one Post-it-Note and write their birthday on the other Post-it Note. When they are finished they will put the Post-it-Notes under the month in which their birthday falls.

They will notice the common characteristic of birthdays in the same month
They will realize that sorting means putting things in groups of like items.

They will notice the bar graph that is produced on the bulletin board and answer questions such as the following:

1. Which month has the most birthdays?
2. Which month has the least birthdays?
3. Are there more birthdays in January than December?
4. What is the total number of birthdays in February and March?
5. What is the total number of birthdays in September and October?

The students will then hold up the 2.07 oz. package of Starburst. They will open it and count the number of candies. They will estimate how many candies are in the 16 oz. bag of Starburst. They will count them to see if they are correct. They will use the sorting sheet to create a bar graph showing how many candies of yellow, red, pink and orange they have? They will answer questions such as the following:

1. How many yellow candies are there?
2. How many red candies are there?
3. How many pink candies are there?
4. How many orange candies are there?
5. Which color has the most candies?
6. Which color has the least?
7. How many red and yellow candies?
8. How many pink and orange candies?
9. How many yellow and red candies?

The students must then divide the amount of candy evenly so that each student has an equal amount.

Performance Assessment:

The students must complete the Sorting Question and Answer sheet with at least 80% correct.

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Sorting Through Life!

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Objectives:

The goal of this lesson is to teach students how to sort objects by recognizing their attributes and if possible, relate them to life. This lesson can be used for kindergarten students.

Materials Needed:

- -refrigerator magnets
- -sea shells
- -attri-cubes
- -nuts (variety)
- -color blocks
- -buttons
- -counting bears
- -marbles
- -old jewelry
- -hair accessories

Strategy:

The above listed items can be used in more than one lesson. In other words, if you select marbles on one day, you can use nuts another day. It really depends on what type of teaching style you prefer or the amount of materials you have. Basically, I enjoy using this as a rotational lesson. Kindergarten students are very capable of doing this lesson in groups and working at a center that has been prepared for them. The teacher can work with the students in small groups. I prefer two to four students in a group.

Begin by placing the objects or items at the center where the students will be working. If you are going to work in small groups, give the students a few minutes to explore the items/objects. Ask the students if they can give the items a name. **Example** - The items you have decided to use are the sea shells. Ask the students questions. What are these? Have you ever seen them before? Where? What do you think of when you see them? This gives the students a chance to call on their experiences in order to relate to the project. Next, have the students look over the different types of shells and put them into groups by shape, color, texture, etc. Next, have the students count the total number of groups. They may even come up with groups that you have not thought about. Basically, this is the way that I work with the students because of the amount of materials I have access to in my room.

Performance Assessment:

Since this lesson is geared towards a kindergarten level, I like to use a check or a minus to reflect whether they understand or not. In most Chicago schools at this time, the standard kindergarten assessment consists of a + (good), / (needs work), and a .(dot-not developed).

One of the best ways to assess a student is to use other materials that he/she has not used. By doing this, it is possible to see if they can transfer or apply what they have studied.

Conclusions:

This is one of my favorite lessons and I use a variety of objects which is incorporated into a unit on attributes. The children love working with all of the different items. It gives them a chance to explore, internalize, grasp, and relate to the subject. It can really enhance the students' mathematical and socializing skills.

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Number Patterns in Pascal's Triangle

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Objectives:

This lesson is designed to enable students at grade 5 or higher to recognize the integers, rows and columns that comprise Pascal's Triangle.

The main objective of the lesson is to enable students to reproduce the first eleven rows of Pascal's Triangle by recalling number patterns given in the lesson without having to look again at the original triangle.

Materials Needed:

Overhead projector
Overhead projection transparency film containing Pascal's Triangle
Overhead projection transparency film containing only blank cells
One photocopy of Pascal's Triangle for each student
One photocopy of blank cells (to reproduce the triangle) for each student

Strategy:

Inform the students that the rows and columns of integers that make up the triangle known as "Pascal's Triangle" contain many number patterns that they can easily recognize and duplicate after participation in this lesson. Begin the lesson by displaying the following rows and columns of numbers via the overhead projector.

```
                         1
                       1   1
                     1   2   1
                   1   3   3   1
                 1   4   6   4   1
               1   5  10  10   5   1
             1   6  15  20  15   6   1
           1   7  21  35  35  21   7   1
         1   8  28  56  70  56  28   8   1
       1   9  36  84 126 126  84  36   9   1
     1  10  45 120 210 252 210 120  45  10   1
```

Point out to the students that each row in the triangle begins and ends with the integer 1. After the students show an adequate indication that they recognize this first pattern, show them that the numbers in alternating rows form columns that must be lined up under each other as the triangle is expanded one number per row of integers. Finally, show the students that the sum of each two successive integers in the row above it is equal to the integer in the row below it and centered between the two integers. The students can then use this information and duplicate Pascal's Triangle on the photocopy of blank cells provided for the purpose of each student duplicating the triangle following the lesson.

Performance Assessment:

Monitor the responses of the students in the class as you point out the above patterns to them and have them tell you what integers will follow in the rows of Pascal's Triangle. Use the blank cells photocopy for each student to make his/her triangle after the lesson without referring back to the original triangle. Quickly collect and correct each student's duplicate triangle. Demonstrate and explain again how to add two consecutive integers to find the integers in the succeeding rows of the triangle if more than three students did not correctly provide all the integers on the photocopy. Issue new copies of the blank cells to those students who did not perfectly duplicate the triangle. Have these students write out the process that produced their incorrect integers and resubmit a second completed copy of the triangle.

Conclusion:

Students can be shown how to identify some of the patterns in Pascal's Triangle and duplicate the triangle in a single lesson. They can then be encouraged to look for some of the many other patterns that exist in the triangle.

References:

Pascal's Triangle: Green, Thomas M., and Hamberg, Charles L. Dale Seymour Publications, P.O. Box 10888, Palo Alto, CA 94303.

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Visuals Patterns in Pascal's Triangle

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Objectives:

1. To use a phenomenological approach to impress upon students the many visual patterns and number patterns that are present in the sequence of numbers that make up Pascal's Triangle.

2. To convince students that they are able to construct Pascal's Triangle on their own without use of notes after the conclusion of this presentation.

3. To encourage students to explore on their own patterns that exist in Pascal's Triangle, but which they were previously unaware.

Materials Needed:

Overhead Projector
Three (3) prepared overhead displays of Pascal's Triangle: one (1) display with all the numbers included, one (1) display with numbers included in the first 4 rows only, and one (1) display with no numbers included in any of the elements.

Presentation:

1. Introduce Pascal's Triangle by showing the completed triangle on the overhead. Explain to class that there are many beautiful patterns in Pascal's Triangle of which they are unaware. Challenge class with promise that each of them can reproduce all the numbers seen in his triangle that is displayed on the screen after this presentation.

2. Remove the display of the completed Pascal Triangle and replace it with the triangle that has four (4) lines completed. Explain that the outer numbers are all "1's" and the inner numbers are always the sum of the two numbers immediately above them. Armed with this information, each student should now be able to complete the numbers in a Pascal Triangle of any size. Call on various students to supply the values for the various numbers in the partially completed triangle that is displayed.

3. Project the blank pattern of Pascal's Triangle on the screen and call on various students to supply the numbers that make up each cell of the triangle. When it becomes apparent that students are confident of their abilities to complete the numbers in each cell of any Pascal Triangle, proceed to point out some of the many number patterns and visual patterns contained in Pascal's Triangle.

Conclusion:

One of the first patterns that can be pointed out is the sum of the numbers of any diagonal. The sum of elements of any diagonal is the number immediately below the last number of the diagonal. Another easily seen pattern is the sum of the rows for any row in Pascal's Triangle. For any row, the sum of the numbers in that row is 2 raised to the exponent of that row. The sum of all the elements of of any number of rows is 2 raised to 1 more than the number of the row, then subtract 1.

Pascal's Triangle also contains the "triangular numbers":

$$T_n = 1/2(n)(n+1)$$

and the Fibonacci numbers. Isaac Newton, in his "binomial theorem", proved that entries in the Pascal Triangle represent coefficients in the expansion of $(x+y)^n$, where n is any counting number.

References:

Visual Patterns in Pascal's Triangle, Dale Seymour Publications (1986). P.O. Box 10888, Palo Alto CA 94303.

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To Classify Beans And Peas

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Objectives:

The students will be able to record information on their bar graph and interpret the information given. To identify five different kinds of beans and three different kinds of peas.

Materials needed:

- ruler
- data sheet
- paper plate
- bag of mixed beans and peas
- pre-labeled bar graph sheet
- box of crayons or markers

Strategy:

Divide the children in groups of four. Ask the children to sort the beans by size or shape to get a feel for grouping. Hand out graph sheets and have each group record their results. Make a bar graph with the whole class and put the beans or peas on it according to type. Use the following questions in a class group discussion:

1. What does it mean to observe something?
2. What does grouping mean?
3. What does it mean to record something?
4. How many different kinds of beans or peas were in your bag?
5. Which bean or pea did you have more of?
6. Which bean or pea did you have the least of?
7. How many beans and peas did you have in all?
8. What are the differences between beans and peas?
9. Which two beans or peas did you have equal amounts of?
10. What is the difference between the largest amount of beans or peas and the least amount of beans or peas?

Conclusions:

The students will realize that the skills they have acquired will be useful in many areas besides mathematics. Other disciplines that utilize graphs are science, geography, economics, and computers.

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Chess Math

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Objective:

Students will be able to reinforce their knowledge of angles by becoming chess pieces on a floor chess board.

Materials needed:

Chess game, masking tape, twine string, rulers or yard stick, poster board or tag board, scissors, black markers and a hole puncher.

Strategy:

Prior to the class session, the teacher should mark off a large chess board on the floor of the classroom with masking tape (A chess board has 64 equal squares with half black and half white).

Each chess piece should be cut from the poster board and marked to identify two kings, two queens, four bishops, four knights, four rooks and sixteen pawns. One king, one queen, two bishops, two knights, two rooks and eight pawns will be designated as black and the other half will be designated as white pieces.

Holes should be punched in the sides of each piece near the top to put the string through, so that the pieces can be placed around the neck of each person involved in the game of Chessmath.

The legal moves that each piece is allowed to execute must also be printed on the pieces of poster boards.

The game begins with designated players stationed on proper squares. The queen must be on her color. The moves will be called by the teacher. After each move the player must call out the angle that was made and the degree of that angle. The player will look on the piece around his neck and try to move accordingly. Points will be given to players according to the degrees they make.

Conclusion:

This lesson has reinforced the knowledge of angles and their values via Chessmath.

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TESSELLATIONS: An Application Of Simple Regular Polygons

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Objective:

The students will develop basic skills making and identifying homogeneous tessellations, both regular and semiregular.

Materials needed:

One overhead projector,
One transparency of tessellation patterns with vertices marked and polygon name listed below,
One set of overhead transparency pens,
Two - four small plastic bingo chips,
One set of plastic regular polygon shapes made from a tessellation pattern consisting of 10 equilateral triangles, 6 squares, 4 octagons, 4 duodecagons,
One set of construction paper regular polygon shapes for each student in the class made from the same tessellation pattern as the plastic overhead polygons,
One set of 6 to 8 construction paper circles of diameter 1 inch in a color to contrast with the floor of the room being used.

Strategy:

The first phase consists of various groups with a large surface for a working space taking about 5 minutes to "investigate" the contents of an envelope containing regular polygon shapes to see what they are and what they can do.

The second phase consists of students working with their own polygon pieces to develop a pattern they can illustrate is repetitive using only one polygon shape. Volunteers should display their results using the plastic display pieces for the overhead. Then conclusion number one is presented by introducing regular homogeneous tessellations from their discoveries.

The third phase consists of combinations of regular polygons being used to develop various 2 polygon semiregular tessellations. These can be illustrated with the use of the plastic polygon pieces for the overhead machine. This should be a somewhat limited display with emphasis on replication for tessellations. Then conclusion number two is presented by identifying semi-regular homogeneous tessellations from their discoveries.

The fourth phase consists of a summary of discoveries made to this point concerning requirements for tessellations gleaned from the previous experiments.

The fifth phase consists of combinations of regular polygons created by students using 3 polygons in each pattern. It is "hoped" that a student will attempt to use an octagon surrounded by an alternating pattern of squares and 3 triangles. If not presented and no equivalent is presented, the octagon should be suggested for continued experimentation until such a pattern is found which contains "holes" or gaps between the consecutive polygons. This will lead to a discussion of the last condition necessary for a tessellation concerning the sum of the angles at the vertex of the tessellation.

The sixth phase consists of a brief discussion of the patterns of 4 squares on the floor outlined with paper tape and having one of the contrasting circles at the common vertex of the 4 squares. This should conclude with the summary of the use of the circle pattern of rotation (360 degrees) at the common vertex to determine true/false tessellation.

The seventh phase consists of a return to the above mentioned octagon pattern, 8-3-3-4, displayed on a chalk board. Continue with this display by inserting the degrees of the angles at the common vertex, 135-60-60-90, to prove this pattern is not a valid tessellation. A reinforcement should be done using previous tessellation patterns displayed on the overhead. An overhead pen or one of the small bingo chips can be used to mark the common vertex while students compute the total degrees found by rotating in a circle about the common vertex.

The eighth and last phase consists of a brief introduction to the more artistic type of tessellations from the regular polygons with ideas concerning the "nesting" of patterns necessary to develop a tessellation. It is possible to consider this an optional phase of unit one since it might also be considered phase one of unit two on tessellations.

References:

Rather than list all the materials used in bibliography form, I would suggest that the person interested in creating such a project obtain the catalogue from Creative Publications. Investigate the many materials available including the overhead projector polygon pieces and wooden polygon pieces which could be used as an alternative to the paper pattern pieces I indicated I used.

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Logic and Reasoning

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Objectives:

The student will use logic and reasoning strategies to classify blocks by their attributes.

The student will be able to recognize one, two and three attribute differences.

The student will use Venn diagrams to form sets and show their intersection.

The student will use the attribute blocks to form ratios.

Materials needed:

Attribute blocks: The blocks used in this lesson may be commercial or teacher made, with these attributes:
Color-red, yellow and blue
Shape-square, circle, hexagon, rectangle and triangle
Size-small and large
Thickness- thick and thin
loops, color chalk and worksheets

Strategy:

1. The students will work in cooperative groups. First let the students examine the blocks, freely playing with them. Direct the students to classify blocks by their attributes: color, shape, size and thickness.

2. Ask the group to place one block on the center of the table and find all blocks that differ by one, two and three attributes.

3. Use the loops to form sets in a Venn diagram. Example: in one loop place a set of triangles and in another loop place a set of blue blocks. Students will notice that these sets must overlap, forming the intersecting set of blue triangles.

4. Write ratios to show the comparison of two sets of attribute blocks. Example: write the number of red circles to the total number of circles, thus forming a ratio.

Conclusion:

The students will use logic and reasoning strategies to process information and solve problems.

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Tower of Hanoi

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Objectives:

(For grades 6 through 12)
1. To discover a pattern.
2. To evaluate an exponential expression.

Materials:

Tower of Hanoi puzzle and circular discs of various sizes.

Procedure:

Pass out five circular discs of different sizes to each student. Have each student draw three large circles on a sheet of paper. Then have them place the largest disc in one of the circles as you place the largest disc of the puzzle on one of the three pegs (towers). Explain the rules of the puzzle as follows. The object is to move all the discs from one tower (one circle) to another tower (another circle). Only one disc can be moved at a time and a larger disc can never be placed on top of a smaller one. The discs should be moved from one tower to another in the least number of moves.

With one disc it only takes one move to place that disc on another tower (circle). Next have the students place the two largest discs in any circle. Have the students try to move the two discs to another circle. Ask them to tell how many moves it took. It will take three moves. Place the smaller disc in either open circle. Then move the larger disc to the other open circle. Finally place the smaller disc on top of the larger disc. Now have the students place the three largest discs in any circle. Allow the students some time to try to move the three discs to another circle. This will take at least seven moves. Move the top two discs to another circle in three moves as explained above. Next move the largest disc to the open circle. Then use three moves to get the two smaller discs on top of the largest disc. Now have the students place the four largest discs in any circle and try to move them to another circle. This will take at least 15 moves. It will take seven moves to move the top three discs to another circle as we just did with three discs in a circle. After moving the top three discs, the largest disc is moved to the open circle. Next the other three discs must be moved on top of this largest disc. This will take seven more moves, however, the first move is crucial. When moving an odd number of discs, you must move the first disc to the circle (tower) that you want all the discs to end up on. When moving an even number of discs you must move the first disc to the circle that you do not want the discs to end up on. At this point you should have the students notice how the number of moves increased, i.e., 1, 3, 7 and 15. Have the students look for a pattern and predict the number of moves for five discs. The number is 31. Give the students a few minutes to see if anyone can come up with the formula - which is $M = 2^n - 1$ where M is the number of moves and n is the number of discs. If no one comes up with the formula give it to them and have them verify it for n equal to 1, 2, 3, 4, and 5. Next have them use the formula to find out the number of moves for 6, 7, 8, and 10 discs. Finally tell them about the legend that a monk has 64 discs on a tower and he moves one every second. When he has moved all the discs the world will end. Have them estimate how long this would be.

Use a calculator to evaluate $2^{64} - 1$. The answer is approximately 589,942,417,400 years.

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Logic

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Objective:

The sixth through eighth grade students will be able to:

1) Understand word problems by use of reasoning techniques
2) Identify the validity or non-validity of the problems
3) Discern which factors are needed for problem resolution
4) Use deduction strategies for problem resolution

Materials:

All materials listed are for an entire class

Overhead projector
worksheets and charts
coins (pennies & dimes)
box of toothpicks
plastic shapes (triangle, rectangle, parallelogram, & square)
forty buttons
a medium size box

Strategies:

1 a. Work in teams of three to four students
Distribute the plastic shapes
Explain to the students that there is a set time limit
Arrange shapes into required pattern(s)
Work cooperatively in teams

b. Work individually to solve another pattern puzzle

c. Have 6 to 12 students work independently while others are working in teams to solve another pattern puzzle

2. Define the word logic

3. Illustrate a logical sequence

4. Illustrate an illogical sequence

5 a. Discuss how logic can be used in daily lifestyles

b. Discuss how logic can be used to solve word problems

6 a. Distribute 12 toothpicks to each student
Place toothpicks into geometric shapes drawn on the chalkboard

Remove the required number of toothpicks to form new shapes

b. Ask students to explain what they did
Organize the steps taken into a logical process

7. Have students preview the handout sheets
Ask students what they think they will need to do
Discuss ways to solve similar problems
Have students find the solutions
Work individually and in teams (as time permits)

8. Distribute the coins to each set of teams
Review problem with students
Have students find the solutions
Explore and discuss whether more than one solution is possible

9. As a follow up to this lesson have students make up word problems
Exchange problems and work in teams for solutions

Conclusion:

Students should feel more comfortable with establishing a process for solving word problems. Teachers should solicit and generate all kinds of questioning about the use of reasoning, elimination, and deduction to solve word problems. The overall process should be both informative and enjoyable.

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Counting Triangles

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Objectives:

The sixth grade student will:

1. Organize, summarize, and record information.
2. Discover a rule or formula that will find the total number of triangles in a figure.

Equipment and Materials:

1. Overhead projector, transparencies, and marker.

2. Transparency displaying one large triangle divided into six small triangles. Make a 1-part triangle, a 2-part triangle and a 3-part triangle to be used as overlays on the large triangle.

3. Teacher-prepared worksheet with six triangles arranged in numerical order from 1 to 6. Each triangle should be equally divided to represent the number to be counted.

Recommended Strategies:

A. Establish a meaningful definition of a triangle.
B. Form small groups and distribute worksheets.
C. Use overhead projector to demonstrate how to establish a counting arrangement by writing a letter name starting clockwise in the triangle (a, b, c, d, e, f). Name all 1-part triangles, name all 2-part triangles and name all 3-part triangles.
D. Summarize by organizing all the data into one table like this:

Triangle Table

Type of triangle	Listing by letter	Number of triangles
1-part	a, b, c, d, e, f	6
2-part	bc, ed, af,	3
3-part	abc, bcd, cde, fed afe, fab	6
6-part	abcdef	1
	Total number of triangles	16

E. Use the second worksheet to count total number of triangles numbered 1-6. In counting the triangles, a pattern should be discovered by students. The pattern is that the total number of triangles is the sum of all counting numbers from 1 to the number of small triangles in the figure.
Example: A triangle equally divided into three small triangles is:

1 + 2 + 3 = 6

Evaluation:

Provide additional opportunities for reinforcement of this concept by using worksheets.

References:

Lenchner, George. **Creative Problem Solving in School Mathematics.** Boston: Houghton Mifflin Company, 1983.

Seymour, Dale. **Favorite Problems.** Palo Alto, Calif.: Dale Seymour Publications, 1982.

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Using Diagrams in Problem Solutions

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Objectives:

Grade Level 7-8
1- Use of tables, graphs, and diagrams to obtain information.
2- Construction of tables, graphs, and diagrams to collect data.

Material:

Mimeographed papers containing graphs, tables, and diagrams.

Strategy:

Presenting a drawing to the class, students will have the opportunity to observe and study how certain data could be obtained by reading tables, or graphs. (bar graphs and line graphs)

Providing a real situation students will construct their own tables and graphs containing the correct information.

Making use of Venn Diagrams the teacher will lead the student to read them and then make their own to solve any given problem.

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Formula Determination

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Objective

1) Student will learn to determine the number of degrees in any convex polygon.

Equipment and Material

Overhead Projector
Geo-Boards
Rubber Bands

Recommended Strategies

Remind the students that the sum of the three interior angles of every triangle has a measure of 180 degrees.

Establish a meaningful definition of a polygon. A polygon is a many sided closed geometric figure.

Using the overhead projector have a transparent geo-board on the overhead projector. Demonstrate the shapes of various polygons by stretching rubber bands around the nails. Take another rubber band stretch it from one vertex to another non adjacent vertex. This is to determine the number of triangles formed. Repeat this operation with various sided polygons. The students will be recording their findings on a chart. A sample chart is below. Prepare a sample chart to pass to each student constituting of data each student should make an attempt to actively collect.

Chart

No of Sides	**Triangles Formed**	**No of Degrees in each Triangle**
----------	------------	----------
----------	------------	----------
---------	------------	----------
.	.	.

After each student has collected the data, he should be able to derive the formula (N - 2)180 which is the desired goal.

Analyze this formula for the student to illustrate how this is used to determined the number of degrees in any polygon with (N) number of sides by the number of triangles that was formed with the geo-boards and rubber bands.

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CLASSIFICATION

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Objectives

1. Motivate students to understand classification.
2. Decision-making and how certain objects relate to the number system.
3. Learn the meanings of words used to express mathematical ideas.

Materials

Bag of groceries

Recommended Strategies

1. Teach counting ideas or skill to be applied in activities.
2. The number system is a method of arranging units into groups so that quantities may be comprehended easily, and then used in computation with accuracy.
3. Teach and build meaning for abstract mathematical ideas that are concrete and representative activities.
4. Teach basic facts.
   a. order
   b. sequencing
   c. arrangement
   d. rearrangement
   e. sorting.

This activity enhances decision making and classification the student will have to think where does cucumbers belong? How about cereal? How about mayonnaise? What about tuna fish? By answering these questions, your students will be forming foods-that-belong-in-certain place group. Some foods are similar, like orange juice and grapefruit. Some are different like hamburger and ice cream. But they have something in common when it comes to classifying groceries.

As each food group is put away you can ask how many items were put in the refrigerator? Cabinet? Closet? This is how counting began.

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Learning by Logic - Total Surface Area

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Objectives:

1. The student will calculate the area of plane surfaces using the formulas for the area of a square, rectangle and triangle.
2. The student will develop the formula for calculating the total surface area of two geometric solids, the cube and rectangular prism.
3. The student will calculate the total surface area of cubes and rectangular prisms.
4. The student will apply concepts to determine the total surface area of a variety of classroom and household materials.

Apparatus Needed

geoboard
rubber bands
overhead projector
transparency film (clear, green, yellow)
markers
small boxes from household materials
yardstick
shoebox kit consisting of:
 plastic pieces of various sizes (poster board may be used)
  4 squares
  4 rectangles
 centimeter grid paper
 centimeter grid ruler
 pencils
 wooden cube*
 wooden rectangular prism*
 construction paper
 small boxes from household products
 small plastic ziplock bags
 paper
 duplicated sheets
 scissors
 tape

* milk cartons can be used to construct a cube or rectangular prism

Recommended Strategy

Using a geoboard and overhead projector, lead students in a discussion of square units. Develop the concept that squares are quadrilaterals with four equal sides, opposite sides parallel and each angle measuring 90 degrees. Develop the concept that rectangles are quadrilaterals with opposite sides parallel and each angle measures 90 degrees, the opposite sides are of equal length. Develop the concept that a triangle is one-half of a quadrilateral.

Write formulas for each geometric figure discussed:

Square........ $A = s \times s$ or $A = s^2$
Rectangle..... $A = l \times w$
Triangle...... $A = 1/2\ (b \times h)$

Students will work in groups of four or five. Each group will receive a kit containing the above listed materials. Students will take from a plastic bag varied pieces of plastic. Examine each and look for similarities that would allow the pieces to be grouped. Next arrange them into similar stacks. Draw them onto the centimeter grid paper, arranging from largest to smallest. Be sure to begin each figure even with a line on the grid paper. Calculate the area of each plane figure, using the three formulas listed on the board.

Given a duplicated sheet containing a variety of shapes, students are asked to divide and conquer. Determine the surface area of the eight planar shapes. The student will find the area of each planar region by adding the sum of the areas of its parts.

Given a cube and rectangular prism, each student will wrap the geometric solid, to develop the concept that surface area means to surround. Draw straight lines, cut out the six sections. Tape the sections to a sheet of paper, look for similarities. Develop a method for determining the total surface area of the cube. Do the same for the rectangular prism. Use this information to develop a formula for finding the Total Surface Area of a cube and rectangular prism.

The Total Surface Area of the cube is equal to the sum of the area of six equal sides:

Cube....................T. S. A. = $6\ (s \times s)$ or $6\ s^2$

The Total Surface Area of the rectangular prism is equal to the sum of six surfaces........

the front and back... $(h \times l)$
both ends............ $(h \times w)$
top and bottom..... ..$(w \times l)$

Rectangular Prism.......T. S. A. = $2\ (h \times l) + 2\ (h \times w) + 2\ (w \times l)$

or....T. S. A. = $2\ [\ (hl) + (hw) + (wl)\ ]$

Use the formulas developed to determine the T. S. A. of other cubes, rectangular prisms, a paper house, the floor and ceiling of the classroom, the painted surfaces of the classroom, household items and drawings on a worksheet. A centimeter ruler and yardstick are provided for convenience. Calculators may be used for this activity. Make sure each answer contains the appropriate unit squared.

Resources...

Lund, Charles. **Dot paper Geometry with or Without a Geoboard**
Oregon State Math. Resource Project. **Geometry and Visualization**
Stokes, William T. **Gems of Geometry**

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Mathematics/Physics

Laws of Probability: Mutually Exclusive–vs–Mutually Inclusive Draws or Playing the Odd's

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Objectives:

I want my students to learn the difference between a mutually exclusive and a mutually inclusive draw and the resulting effect. This presentation could be used for students from grades 8 thru 16 with relative ease.

Material(s):

The materials used for this presentation are for a class size approximately of 25 students. They will need the following materials:

Five (5) to Ten (10)	Decks of playing cards
Five (5) to Ten (10)	Sets of Dice
25 or More	Lottery playing cards of various games:

Example: Big Game, Lotto, and Little Lotto.

Strategy:

To show the students how to cut down the odds or reduce the probabilities of losing by using Fractions and Decimals to show the better odds or probabilities**.**

Performance Assessment:

The performance assessment is to see if the students understood the use of fractions and decimals to increase their changes of winning. If they actually put this strategy to use and become successful at using it, then the money they win will be their grading rubric.

Conclusions:

This presentation was not intended to influence people to gamble. It was intended to show you how the Gaming Industry, which is Government Regulated, uses fractions and decimals to cut down their chances of losing.

References:

The terms mutually exclusive and mutually inclusive and their definitions were taken from the following book: Book 2 – Modern Algebra and Trigonometry structure and method, Revised Edition, Dolciani, Berman, Wooton.

Probability

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Objective:

To observe the relationship between theoretical probability and experimental results. This activity would work with a seventh grade class. However, students in grades sixth and eighth grade would enjoy this activity.

Materials Needed:

A. glue, notepad, ruler, pens, scissors, 2 sheets of different-colored poster board, large sheet of graph paper
B. 6 blue marbles, 4 red marbles, and 2 yellow marbles

Strategy:

Using the coins students will be able to realize probability is useful in our daily life. Probability helps us understand the world around us and organize information in ways that make it easier to comprehend.

1. Students will insert 6 blue marbles, 4 red marbles, and 2 yellow marbles into a small bag.
2. Each student will reach into the bag 40 times and chart how many times marbles of each color were selected.
3. Using graph paper students will record their findings.
4. Students will compare the relationship between the theoretical probability and the actual results of our experiment.
5. 6/12 (1/2), 4/12 (1/3), 2/12 (1/6), are the theoretical probabilities of selecting at random, respectively, each of the three colors.

Performance Assessment:

I will use a grading rubric for this lesson. This rubric contains the Chicago Public Schools' Curriculum Framework Statements.

Conclusions:

Students will be able to identify the phenomenological approach to mathematics. The theoretical probabilities should be observed in the results of our experiment.

Reference:

Family Math Book

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Probability of Childhood Games

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Objective:

Students will find probability of several different events theoretically and experimentally. This lesson is intended for junior high students.

Materials Needed:

1. 5 or 6 spinners evenly divided into 6 colors.
2. Three-color spinner divided into a half and two quarters.
3. A bag of fifteen marbles (five of one color, four of another, etc.).
4. A set of dice and a Monopoly board.

Strategy:

Students in groups will migrate from one station to another during the period with about ten minutes given to each task. Each group should have a recorder to write down the results of each experiment.

The following is a description of each experiment and what to do for each:

Experiment 1: The four color spinner experiment involves a spinner for each participant and the participants will spin the spinner twenty times and record on which color the spinner landed.

Experiment 2: The six color spinner follows the same procedure as the four color spinner of Experiment 1. A total of twenty spins per group is again suggested.

Experiment 3: When I did this experiment as my mini-teach, I used a unique spinner. The spinner with marbles is a spinner from the game **The Magnificent Race**, a favorite game of my childhood. Unfortunately, the game is no longer being made. However, you can simulate the results using a bag of marbles with five of one color, four of another, three of a third, two of a fourth and one of a fifth. This will give you a total of 15 marbles. Have each group draw a marble from the bag, replace it, and draw again until they have drawn a total of twenty times. Record the results.

Experiment 4: The Monopoly board task is for students to determine which space on the Monopoly board is landed on the most. To do this, starting at Go, roll the dice and record where on the board the player would land. Continue doing this starting at Go each time until the dice have been rolled twenty times.

After students have finished all the experiments and recorded them, the next step is to compare the experimental probability from the results of the experiment to the theoretical probability. The theoretical probability can be determined for each of the experiments in this way:

Experiment 1: This spinner is broken up into one half and two fourths, so theoretically, the probability for landing in each of the spaces should be one half, one fourth, and one fourth. This means that theoretically the spinner should land in the half space half the time and so on.

Experiment 2: This spinner has evenly divided spaces, so theoretically the spinner should land in each space the same number of times. This may or may not happen in reality. You need a whole lot of trials to match the theoretical probability.

Experiment 3: This spinner holds a a total of fifteen marbles with more of some marbles than others so the theoretical probability depends on the number of marbles of each color. The theoretical probability is the number of marbles of a particular color over the total number of marbles. For example, if you have five marbles of one color, the probability of that color being picked is five over fifteen.

Experiment 4: The Monopoly experiment is rooted in the classic probability experiment of rolling two dice. Students can make a chart to determine which rolls come up more frequently than others and then match the rolls to the spaces on the Monopoly board. The most common roll should be seven.

After the groups have finished with their individual experiments, compile the data for each experiment from all the groups. You should find that the compiled data of the entire class should be closer to the theoretical probability than the data of the individual groups.

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Probability

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Objective:

The students in grade levels 5-8 will learn, discover, explore and tabulate a table of the number of times a specific event can occur. In this activity, students consider the results of two types of events. One involves repeated sampling with replacement; the other, without replacement. In the first case, the events are independent; in the second case, they are dependent.

Materials Needed:

Groups of two will need:
1. 3 Paper bags
2. Penny or any coin
3. 3 sets of five chips numbered 1, 2, 3, 4, 5
4. Paper/Pencil

Strategy:

1. The class will be divided into groups of two. Each group will be given 3 paper bags. In one bag labeled A, there will be 5 chips numbered 1-5 and a penny. In the second bag labeled A, there will be 5 chips numbered 1-5. In the third bag labeled B, there will be 5 chips numbered 1-5.
2. One person in each group will be asked to remove the penny from the bag labeled A and place the three bags to the side. One person in each group will look at the penny to determine the total number of sides of that penny.
3. After determining the number of sides of a penny, the group will flip the penny once to determine the likelihood of getting a head.
4. The instructor will write the definition of probability and the formula for probability.
5. The group will flip the coin twice and write a table of the total number of outcomes that can occur when flipping a coin twice while the instructor writes the table on the overhead projector. The instructor will show the students how to write the table in a uniformed pattern. For example, HH, HT, TT, TH, beginning with the heads as starting the pattern.
6. The student will use their probability formula to determine that P=1/2x1/2=1/4 with each 1/2 being each flip (2 flips) and the probability of flipping two heads is 1 out of 4 or 1/4.
7. The group will flip the coin 3 times and determine the table of 3 flips using their own pattern and also, write the probability of 3 flips.
8. The group will then place the two bags labeled A on their desk and place the penny to the side. The student will need to determine the table for all of the total possible outcomes that can occur from drawing 5 chips in each of the two bags and replacing the chips. The group will take turns drawing 2 chips (1 chip from one bag and 1 chip from the other bag) and writing down the results. The group will continue to replace the chips in the bag after the 2 chips are drawn. The group will need to determine that there are 25 total possible outcomes that can occur with replacement in independent

sampling.

9. The group will then place the one bag labeled B, draw 2 times, and write down the results of the first and second draw. The group will not replace the chip from the first draw in the bag. For example, if the first draw was a 2, the 2 would not be replaced in the bag. The student will need to determine the table for all the total possible outcomes that can occur from drawing 5 chips from one bag and not replacing the chip from the first draw. The group will need to determine that there are only 20 total possible outcomes that can occur without replacement in dependent sampling.

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Phenomenological Probability

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Objective:

Students will find the difference between theoretical and experimental probability in three different experiments. This mini-teach is designed for junior high students.

Materials Needed:

* A pair of dice for each student
* Ten or more colored marbles and a spinner (or bag)
* A standard deck of 52 cards.

Strategy:

Set up three stations with the materials mentioned above at each station. Give students about twenty minutes for each activity. Blow a whistle or clap between each activity and then have groups switch activities. The following is a description of each activity:

1. Rolling Two Dice: Have each student roll two dice 20 times and record each sum. When the experiment is completed, have each student come up with a group probability by combining the individual experiments. Experimental probability is the number of times a sum is rolled divided by the number of rolls (20).

2. Marbles in a Spinner: For this experiment, I used a spinner that allowed one marble to land in a space on the spinner. You may do the same experiment without the spinner using a bag and having students pick a marble out of the bag 20 times. Make sure you have different color marbles of different amounts so you have different probabilities for each color. Compute experimental probability by keeping track of how many of each color are picked or land in the spinner. Experimental probability here is the number of the color picked divided by the total marbles picked.

3. Card Trick: Have each student in the group pick a card from the deck, shuffle the cards and pick another card five times. The student will pick a total of five cards. To determine experimental probability, find the desired outcome such as number of face cards, over the total numbers of cards drawn.

After all the experiments are performed and experimental probabilities are found, compare them to the theoretical probabilities of each experiment. You may determine how close the two are as fractions, decimals, and percents.

Performance Assessment:

An easy performance assessment of this lesson would be to use the same experiments with slight modifications such as adding one die,more marbles,or changing the card events. You can thus assess student understanding of probability using the experiments and have them compute them on their own by writing up their own calculations from the experiment and comparing them to the theoretical probability.

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Mean, Median, Mode, etc.

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Objectives:

The main objective of this mini-teach is to have students in grades four to twelve generate their own data and then analyze their information.

Some of the ideas that could be taught are:

- mean, mode, and median
- histogram
- bar graph
- probability
- circle graph

Materials Needed:

- A piece of ribbon or rope that is at least 20 inches long
- A package of post-its or a bunch of little squares of paper about 1.5"x1.5" or 2" x 2"
- A roll of masking tape
- A classroom set of M&M candy bags
- A wall or blackboard
- A calculator

Strategy:

Hold up a piece of rope or string. Have the students write down the length of this rope or ribbon on their piece of paper. Then have a number line on the board. Have the students come up to the board and place their estimates on the board with their post-its on the number line.

Depending on the level of the students, you could teach or introduce an appropriate lesson on analyzing the data from a simple bar graph, quartiles, box and whiskers, outliers, to standard deviation.

This demonstration could also be done by guessing the number of M&M's in a cup. The results would be similar.

Lower grade students could do circle graphs of the contents of individual bags.

Performance Assessment:

I can tell how much students have mastered these concepts through a discussion or a written evaluation.

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Paper Toss Shootout

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Objectives:

Demonstrate a phenomenological approach to teaching mathematics.

Inspire others to use the approach.

Objectives (Grade 8):

Use class data to calculate percentages.

Participate in group activity.

Relate activity to NBA stats.

Calculate select percentages for NBA Finals data.

Materials:

waste baskets
liners for baskets
official "paper toss" paper
NBA data worksheet

Recommended Strategy:

Place baskets 8-9 ft. from marked foul line.

Select groups.

Throw paper ball at basket three times per person for practice.

Throw paper ball at basket ten times per person.

Record number of hits per person within the group.

List names and number of hits on board.

Calculate individual and team percentages for ten shots.

Review or demonstrate how to calculate percentage for eight shots.

Throw paper balls at basket eight times per person.

Calculate individual and team percentages for eight shots.

Combine number of hits per person for ten shots and eight shots and calculate individual and team percentages for eighteen shots.

Determine highest individual and team percentages.

Calculate field goal and free throw percentages for NBA Finals.

1993 NBA FINALS

MICHAEL JORDAN

	Minutes	Field Goals	FG Attempts	FG Percent- age	Free Throws	FT Attempts	FT Percent- age	Total Points
Game 1	43	14	28		3	4		31
Game 2	40	18	36		4	5		42
Game 3	57	22	52		3	6		44
Game 4	46	21	37		13	18		55
Game 5	44	16	29		7	10		41

CHARLES BARKLEY

	Minutes	Field Goals	FG Attempts	FG Percent- age	Free Throws	FT Attempts	FT Percent- age	Total Points
Game 1	46	9	25		2	3		21
Game 2	46	16	26		6	13		42
Game 3	53	10	21		5	9		24
Game 4	46	10	19		12	15		32
Game 5	42	9	18		6	7		24

1993 MATH PAPER TOSS SHOOTOUT CHAMPS

(Class) BORITA KHIM

(Staff) ART DIVITO

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Statistics of Mars*

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Objective(s):

To use a realistic situation as a means of collecting data.
To group, display, and interpret information by sorting and arranging data to construct frequency graphs.
To display and interpret measures of central tendencies.

Materials needed:

3 oz. paper cups
Bags of SKITTLES and/or M&M's (*candies of Mars, Inc.)
Worksheet: Color Sorting Table
Graph sheets: Pictograph, Bar Chart, Pie Chart
Worksheet: Mean, Mode, Median

Strategy:

Put students into cooperative groups and give each group a bag of SKITTLES and/or M&M's, five 3oz. paper cups, and a Color Sorting Table worksheet.
Sort and count the SKITTLES by color and fill in the worksheet.
Have each group construct a different type of graph (e.g., pictograph, bar, pie, etc.).
A Reporter from each group will explain their graph, ease of construction and information displayed. Also, have the reporter fill in their group data on a master Color Sorting Table provided on chalkboard.
Have each group select one color to find the mean, mode, and median for the numbers on the master Table.
Compare the results with the proportions reported by Mars for the five colors: Red - 20%; Purple - 30%; Green - 20%; Yellow - 20%; Orange - 10%.
Predict the proportion of each color for an unopened bag.
Have each group do an oral presentation of their results.

References:

Norwood, Karen, and Yvonne Coston, "Graphs of SKITTLES", **Arithmetic Teacher 40** (April 1993):454 - 456.

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Averaging

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Objectives:

This lesson is appropriate for sixth graders.
1. Student will be able to identify the range.
2. Student will be able to recognize the score that occurs most frequently in the distribution.
3. Student will be able to locate the middle point in the distribution.
4. Student will be able to find the average of a given set of numbers.

Materials:

Calculators
Group (4 students)
Index cards
Measuring tapes
Test papers

Recommended Strategy:

1. Write Test results on the chalkboard.
2. Give a brief introduction about the importance of the "Measures of Central Tendency".
3. Introduce the terms RANGE, MODE, MEDIAN and MEAN.
4. Distribute the Test results.
5. Subtract the lowest score from the highest score.
6. Find the score that occurs most frequently in the distribution.
7. Arrange data in numerical order. Locate the middle point in the distribution. For an even number of scores, there will be two middle numbers. Add these numbers and then divide by two.
8. Find the sum of the scores and then divide by the number of scores.

Activities:

1. Divide students into groups. Each must find the RANGE and MEAN of
   a) heights
   b) distance from home to school
   c) time spent watching TV
   d) students in the class
   e) sit ups done weekly

2. Games
   a) BOWL-A-RAMA. Each bowler has an average of 90 at the end of the sixth game.Students have to complete the chart to show each bowler's score in the 6th game.
   b) One student is selected from each group and is given a card

with a distribution of numbers to find the MEAN, MEDIAN and MODE. The winner chosen is the student with the same number for each MEASURE of CENTRAL TENDENCY.

References:

"**Modern Elementary Statistics**" by John E. Freund. 4th Edition.
"**The Numbers Game**" by Robert S. Reichard.

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PROBABILITY

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Objectives

The student will:

1) Understand the concept of probability and the basic probability formula.
2) Will be able to predict the possible outcomes of an event.

Materials

Six golf balls:	Paper plates
3 yellow	Plastic lids
2 white	Paper fasteners
1 orange	Colored marker

Recommended Strategies

Review the definition of probability. Use golf balls to demonstrate the basic probability formula, which is, the probability of an event is the fraction of the total number of outcomes that cause that event to occur. For example, if there are 3 yellow golf balls, 2 white, and 1 orange, what is the total possible outcome or set of choices that can be selected? (6) What is the probability of selecting a yellow ball? (3/6) A white ball? (2/6) An orange one? (1/6)

The number wheel, which is made by using a paper plate, a piece of plastic for the pointer, and a paper fastener, can be used to demonstrate the probability of a particular outcome after a number of trials. It can also be used to show the probability ratio, the number of outcomes, the ratio of outcomes to trials, and the percent of outcomes to trials for each number on the wheel.

To further enhance the learning of the above objectives, the student can complete an experiment at home which involves tossing a coin fifty times. The same information that was found using the number wheel can be found in the coin experiment.

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Probability

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Objectives:

The students will derive a general formula for the probability of a given event given each possible outcome is equally likely.

Apparatus Needed:

6 dice
30 colored balls (1 each of five different colors)
6 coins
6 paper plate holders
6 plastic cups
6 paper bags
19 ping pong balls (numbered from 0 to 18)

Recommended strategy:

The students were told they had an opportunity to win a prize in today's class by playing the lottery. They were to pick a 3 digit number, a 4 digit number (repeats are allowed) and a combination of 4 numbers from 1 to 18 (no number could be chosen twice).

The students were divided into groups of 3 or 4. Each group received a paper bag containing 1 die, 5 colored balls (1 of each color-blue, green, yellow, orange and pink), 1 coin, 1 paper plate holder and 1 plastic cup. Each group had to conduct three experiments.

1. Flip the coin 50 times into the paper plate holder, record the results (heads or tails).
2. Pull a ball from the bag, record its color, replace the ball and repeat this process a total of 50 times.
3. Use the cup to shake the die. Roll the die into the paper plate holder. Record the result and repeat the process 60 times.

As a class the data from each experiment was collected. The students were asked questions such as: Were the results of each experiment what you would have expected? What would you expect if we were to repeat the process 1000 times? 10,000 times? 10,000,000 times?

The class then generated the formula for the probability of an event P(E)

P(E) = **number of favorable outcomes**
number of possible outcomes

Then the class discussed whether or not the formula will tell us exactly what will happen for a given event. More examples were discussed.

The "lottery" ended the lesson. Students with a knowledge of permutations and combinations can calculate the probability of each event.

$$P(\text{3 digit number}) = \frac{1}{10^3} = \frac{1}{1000}$$

$$P(\text{4 digit number}) = \frac{1}{10^4} = \frac{1}{10{,}000}$$

$$P(\text{4 number from 1 to 18}) = \frac{\mathbf{1}}{\frac{\mathbf{18!}}{14!4!}} = \frac{\mathbf{1}}{3060}$$

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MODELING PERMUTATION GROUP

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Objectives:

Throughout this unit the students are: to construct equilateral triangles on cardboard; to develop the transformation concept with a one to one correspondence; to generate the rotation and reflection table; and to deduce from the model the abstract axioms of a group.

Behavioral Objectives:

The students will achieve practical knowledge of abstract concept of a group and will verify this through testing with a desired goal of 85% success.

Materials:

- A Overhead Projector
    1. Large Plastic Model
        - a. equilateral triangle with circumscribed circle
        - b. square with circumscribed circle
    2. Transparencies
        - a. Transformation
        - b. Rotation and Reflection Table
        - c. Algebraic axioms for a Group
- B Each Student needs
    1. Paper with a reference circle
    2. Cardboard Equilateral triangle
    3. Cardboard Square

Strategy:

A Background

There are many subject areas in Mathematics which would be enriched with this presentation. This should be introduced to a class where student cooperation has been well established. The teacher must be extremely careful to instruct the class in the correct way of formulating the transformations.

B Activity Outline

1. pass out model triangles to students
2. label the triangles in a clockwise way A,B,C,
3. model transformations on the overhead
4. discover individually the finite elements under the definition
5. create table of rotations and reflections
6. observe patterns within the table
7. name these patterns or laws
8. define algebraicly the group
9. verify the model with its laws as a group

C General Plan

With the large equilateral triangle on the overhead demonstrate the concepts of rotation and reflection. Then allow the student to discover all finite possibilities.

Once the elements are named start gnerating the table with the six elements. From the observed data verify that closure, identity element, inverse for each

element and the associative axions or laws hold for the newly created table. Continue to extend the binary operation to three elements by using the associative
2
law and then to any number of elements operating together.

Show on the overhead the list of definitions for an abstract group. Again affirm that the patterns created by the transformations of the equilateral triangle form a set of elements which is well structured set of axioms with the the binary operations of the transformation necessary for a group

D. Overhead Transparencies

1. One to One transformation of Vertices

Name of Vertex — Transformed to Position held by former Vertex

A goes to B
B " " C
C " " A call this R1

A goes to C
B " " A
C " " B call this R2

A goes to A
B " " B
C " " C call this R3

A goes to A
B " " C
C " " B call this ra

A goes to C
B " " B
C " " A call this rb

A goes to B
B " " A
C " " C call this rc

2. Table of Rotations and Reflections of a Equilateral Triangle

"O"	R1	R2	R3	ra	rb	rc
R1]	R2	R3	R1	rc	ra	rb
R2]	R3	R1	R2	rb	rc	ra
R3]	R1	R2	R3	ra	rb	rc
ra]	rc	rb	ra	R3	R1	R2
rb]	ra	rc	rb	R2	R3	R1
rc]	rb	ra	rc	R1	R2	R3

3. Definitions

A. Group "G" is a set of elements (a,b,c,d,e,...) and a binary operation called product "O" such that the following axioms hold:

1. Closure: Form every ordered pair a,b of elements of G the product a"O"b = c exists

3

and c is an elements of G.

2. Associative Law: (a"O"b)"O"c = a"O"(b"O"c)

3. Existence of Unity of the Identity element
An element "E" such that a"O"E = E"O"a =a for every a an element of G

4. Existence of Inverse of any element
For every a of G there exists any element a^{-1} of G such that a^{-1}"O"a = a"O"a^{-1} =E

B. Dihedral Group

The one to one mappings of a set onto itself which preserves a property usually form a group.

Symmetries of a geometric figure are of this kind. These are the congruent(distance-preserving) mappings of the figure onto itself.

The symmetries of a regular polygon of sides larger than or equal to 3 form a group called a Dihedral Groups of order 2n.

It can be shown within these dihedral groups that

$(Ri)^n$ =E where E is the identity element and i = 1,2,3,..(9n-1)

$(ra)^2$ =E , $(rb)^2$ =E, $(rc)^2$ =E or for any reflection of the dihedral group squared

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Boomerang

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Objectives:

This lesson can be effectively used with grades 4-12.
* Estimation of angles in degrees.
* Estimation of distances in feet or meters.
* Data collection and histogram analysis.
* (optional) Study gyroscopic precession and aerodynamics.

Materials Needed:

* Two 12-inch rulers (shatter-resistant) per group/student.
* Rubber bands and/or strong tape.
* Protractor per group/student.
* TI-81/82 per group.
* Data collection sheet per group.
* Two skewers or sticks with marker flags per group.
* One yard or meter stick per group.

Recommended Strategy:

Have students form groups of two. Discuss with students how a boomerang is designed to return when thrown (Australia and geography can be included). Show how to make a boomerang by crossing two rulers and holding them together with crisscross rubber bands or tape. Demonstrate how a boomerang is thrown over-hand like a baseball. Show arm positions as: straight-up/vertical (zero-degrees); shifted to the side (30-degrees); shifted to the side (60-degrees); and shifted to the side/horizontal (90-degrees). Distribute two rulers, rubber bands or tape, protractor, yard/or meter stick, two skewer markers, and a data collection sheet to each group. After each group has made their "X" shaped boomerang, explain that each group must measure and mark a distance of 20 yards as a throwing range. Each student will have three throws in each of the arm-shifted positions: 0, 30, 60, and 90 degrees. Their group partner will record the estimated maximum distance reached for each throw and did it return or not. Take the students outside and assist them with the activity/data collection.

When the data collection sheets are complete return inside and use the data to create a histogram for angles thrown and distance reached. TI81/82 calculators can be used to assist students in making histograms and analysis of data. Have each group explain their histogram and their conclusions regarding whether or not angle thrown effects the flight of their boomerang. Other factors such as wing profile, air resistance, force thrown can be discussed. Lesson can be extended by introducing the concept of gyroscopic precession, which is the physics principle causing a boomerang to return (possible library assignment).

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How Much is a Million?

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Objective:

This lesson is designed for Grades 7-8. Students will estimate how much a million of something weighs.

Materials Needed:

Five boxes of cereal (box of cereal with total weight removed), calculators, scale, and measuring cups.

Strategy:

*****Write information on board: Cap'N Crunch cereal has been contracted to deliver a million pieces of cereal to the Olympic Village. Your job is to determine how many boxes of Cap'N Crunch equals a million, how much it will weigh and how much it will cost to send the boxes to the Olympic Village.
*****Write on board the cost of shipping per ounce or gram.
*****Divide the students into groups of four.
*****Distribute a box of cereal, calculator and measuring cup to each group.
*****Place scales on table.
*****Each group adds data to chart on board.
*****Formula: Determine the total weight of the cereal.
*****Weigh and count a small portion of the cereal.
*****Multiply the # of pieces by the total weight in the box.
*****Divide one million by the # of pieces. This will give the # of boxes.
*****Multiply the weight of one box by the total number of boxes.
*****Multiply the total number of boxes by the shipping costs.

Performance Assessment:

The students should be able to determine the answer by using skills that were previously taught: estimation and measurement.

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Rocket High

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Objective:

Students will reinforce their measurement skills. Students will manipulate a launcher to create specific angles. Students will be introduced to the concept of tangents. This is for the 7th and 8th grades.

Materials:

Each group of four students will need:
-A water rocket and a pump.
-Launchers to rest the rockets against.
-Protractors to measure the angles at the launch site.
-A tape measure.

Strategy:

1. Students will determine what angle will launch water rockets to the highest altitude. Students will use the tangents of angles to determine the height. The angles to be used are 30, 45, 60, 75, and 90. Students will launch the rockets at the five different angles listed above. Use two ounces of water for each launch and pump 15 times.
2. Students will measure the distance from the launch site to the spot where the rocket is at it's highest altitude.
3. Students will record this data. Example: 30 degrees, 14 ft.
4. Students will then find the altitude by using the formula tangent of the angle = opposite/adjacent. Example: tan 30=x/distance from launch site to highest altitude.

Performance Assessment:

Students will turn in their finished data sheet. Observations of the students will be noted during the experiments to determine their use and understanding of a protractor. Students will need to use data from a chart and record accurate data in order to complete their data sheet.

Conclusion:

For the purpose of this experiment, air resistance and wind will be ignored. Students will learn that the rockets will reach the highest altitude when the rockets are shot from the higher degree of angles.

References:

Sneider, Cary I. **Experimenting with Model Rockets.** The Regents of the University California. Berkeley, California. 1989.

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Making Ice Cream

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Objectives:

This lesson is for grade levels 5th through 8th.

1. After the lesson the students will be able change a recipe to arrive at the amount of each ingredient needed to serve a given number of people.
2. The students will explore, observe, examine, measure and mix the ingredients provided.
3. The students will convert metric units to the English units of measurement.

Materials Needed:

Zip-Lock Freezer Plastic Bag (27 cm x 28 cm)
Zip-Lock Freezer Plastic Bag (18 cm x 20.3 cm)
Ice (enough to fill the larger bag half full)
Salt (90 ml or 90 g)
Spoons (enough for the members in your group)
Towel or Newspaper

Strategy:

The students will solve the following problem by changing it to the English units of measurement.
This recipe makes four servings of ice cream. This recipe serves eight.
Ingredients:

125 ml milk	Change to:
15 g sugar	Change to:
1.2 ml Vanilla	Change to:

Fill large Zip-Lock Freezer bag half full of ice.
Measure liquid and dry ingredients.
Combine milk, sugar, and vanilla in small Zip-Lock Freezer bag.
Seal--squeezing out all the air.
Place the small sealed bag containing the milk mixture into the large bag containing the ice.
Add salt to the ice.
Seal again, squeezing out all the air.
Wrap the bags in a towel or several layers of newspaper.
Roll, or shake back and forth, until mixture reaches a thick ice cream appearance.
Enjoy.

Performance Assessment:

The students must change a different recipe from the metric units of measurement to the English units of measurement. Then they must double the recipe.

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Games Using Multiplication

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Objectives:

Students will play two games that will reinforce their multiplication facts as well as their addition skills.

Materials Needed:

1) three or four games of dominoes
2) paper and pencil
3) 24 paper cups

Strategy:

First ask students to give a definition of the word multiplication. After all responses have been put on the board, write down the following definition: multiplication is a short way of adding or counting equal numbers. Place eight cups on your desk, 3 in one pile and 5 in another. Ask one student to come up and count the number of cups. Then ask them to explain how they counted them. Next, take one cup from the pile of 5 cups and put it in the pile with 3, making 2 equal piles of 4. Explain that there are two ways of counting these cups; by adding, or by multiplying 4*2. If you put up two more piles of cups with four cups in each, you could count them or simply multiply 4*4. Explain what each number stands for. Add two more piles of four cups and show how multiplication is quicker and shorter. Have someone count the number of shoes in the class by counting, and have someone calculate it by multiplying.

Next have students take out a piece of paper and a pen. Have them make a square grid on their paper by drawing three vertical lines equal distances apart inside the grid. Then draw four horizontal lines inside the grid. Show that you can count or multiply to find out how many boxes there are. Have students fill in each box with a number between 0-81. This game is called math bingo. The teacher will call out factors for which students are to determine whether they have the product. If they do, they are to write the factors in the appropriate box. The first person to get four across or five down is the winner. The winner calls out the next group of factors.

The next game is called dominoes. In this game students may lay dominoes only with the same number next to each other. For example, a domino displaying a 1-6 may only be played with a domino displaying a 1 or a 6. The 6 would have to touch the 6 or the 1 would have to touch the 1. Scoring is done by calculating the number of points on the outside. If the number of points on the outside add up to a number that is a multiple of five, that player receives that amount of points. Students must call out the points on the board when they play a domino, whether it is a multiple of five or not. The first person to 150 is the winner. Students should be put in groups of 5 or 6. They will take 5 or 4 dominoes respectively without showing anyone. The person with the 6-6 domino plays first. The first person to get rid of their dominoes wins the hand. All remaining dominoes are added up and rounded to the nearest 5 and given to the winner's total.

Performance Assessment:

Students will be given a short timed quiz which will require them to use their addition and multiplication skills.

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Napier's Rods

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Objectives:

Reinforce multiplication facts.
Examine Napier's Rods in relationship to multiplication.
Enhance students ability to understand place value.

Materials Needed:

Napier's grid sheet *
Tongue depressors or popsicle sticks (11 per student)
Scissors
White glue

Recommended Strategy:

Place simple multiplication problems on the board using one digit multiplier and one digit multiplican. Have the students come up to the board to work out the problems. As a group check answers.

Introduce Napier's Rods as a device related to multiplication.

Pass out the materials.

Cut the grids into vertical strips.
Glue these to the sticks, thus making "rods".
Cover one side only on the sticks.

To see how the rods work, find 3 x 46 by placing, side by side, these rods: INDX, 4, and 6. You should have 3, 1 over 2, 1 over 8.
Add these numbers diagonally making sure to add the numbers within their columns. So, 3 x 46 = 1 3 8

These rods also will work for multiple-digit factors. You probably will have to write down each partial product as you work.

Performance Assessment:

Evaluation will consist of correct products and checking to make sure rods are properly lined up so that diagonal adding keeps digits in proper place value column.

Reference:

Math Activities With Simple Equipment, Dr. John L. Ginther.
Book can be found in the file cabinet in the math room.

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"The Golden Rectangle"

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Objectives (Staff):

Demonstrate a phenomenological approach to teaching mathematics.

Inspire others to use the approach.

Present new (to most participants) concepts.

Reinforce skills.

Objectives (Grades 6-8):

Measure using metric units.

Calculate averages.

Compare and round decimals.

Use calculators.

Examine Fibonacci Sequence and Golden Ratio relationship.

Relate mathematics to real-life situations.

Materials:

Measure in advance and select items whose sides are in the approximate ratio of 1:1.6.

file cards (assorted sizes)	envelopes	charge plates	photos
greeting cards (assorted sizes)	invitations	pamphlets	books
graph paper			

Recommended Strategy:

Measure items and calculate the ratio of longer side divided by shorter side.

List quotients on the chalkboard and discuss similarities.

Calculate average.

Measure height and the distance from the top of the head to the middle finger tip with arm extended to one side and calculate the ratio of the two measurements.

Calculate group average.

Compare the ratio of body measurements to the ratio of measured items.

Determine a pattern and complete the sequence:

1, 1, 2, 3, 5, 8, 13, 21, ...
(Additional numbers are optional.)

Calculate the ratio of two successive numbers:

1/1, 2/1, 3/2, 5/3, 8/5, 13/8, 21/13

(The ratio 21/13 equals 1.6154 rounded to the nearest ten-thousandth and represents the ratio of the sides of a golden rectangle.)

Compare the ratio of a golden rectangle to ratios of body proportions and selected items.

Measure sections of layouts in magazines and newspapers and relate to golden rectangle.

Make spirals.

Look for golden rectangles at school, home, and other places.

Performance Assessment:

Groups should look for five pictures or sections of magazines whose dimensions appear to represent the sides of a golden rectangle. Measure and record length and width and calculate the ratio of the sides (to the nearest hundredth). Determine the average for the five items. The teacher should compare the groups' results to the golden rectangle ratio.

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Paper Folding to Make Cubes

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Objectives:

Students will examine patterns of figures composed of six-squares and predict which of the twenty presented could be folded to make a cube. Then students will fold large-scale patterns of these figures to confirm their hunches. This exercise will develop the student's ability to visualize three-dimensional objects from two-dimensional patterns.

Materials:

Overhead projector transparencies of the pattern sheet and the record sheets; printed copies of the same sheets, one for each student; scissors, marking pens, etc. Construction or other extra-heavy weight paper to make multiple-quantities of the patterns, made with ruler, protractor, X-Acto knife and ball point pen.

Strategy:

Group students into cooperative learning teams of three or four. Ask each team to close their eyes and visualize a "cube." Is it a box? Are the sides (faces) identical or different? Is the box ("cube") open or closed? Can they name any everyday objects which have cubical shape?

Then distribute the pattern and record sheets to each team. Have them decide if a pattern will fold into a cube. Mark answers on the record sheets. Teams will report their conclusions to the teacher who will enter results on the transparency.

Finally, distribute sets of the large-scale cut out patterns to each team and ask them to fold each to make a cube. As the pattern numbers will match the printed pattern sheet, the team will be able to compare, discuss and perhaps revise their original judgements regarding foldability.

With better or older classes, this unit may be extended by asking the class if they are familiar with games played with cubes. Many will respond, "Dice" or "Craps." Enter a discussion of how the faces are numbered on such a game piece: Opposite faces are numbered to add to seven. Then distribute a third page to each team containing just the successful folding patterns with only a few of the faces numbered. The team is to consult and decide upon the numbers to be entered on the blank faces to make legal dice.

Acknowledgement:

Mr. Larry Freeman, of Kenwood Academy, my group's mentor and also a member of the SMILE staff in the Summer of 1993 has been of great help in making available his personal library materials and in offering many helpful suggestions for this project's development.

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Integer: Tic-Tac-Toe Four In A Row!

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Objective:

To use a phenomenological approach to the introduction of integers using a coordinate plane and ordered pairs.

Materials needed:

Chalkboard, color chalk, coordinate grid (drawn on the chalkboard), numberline, and a large visual thermometer. Maps are optional.

Strategy:

Discuss integers as a subset of the real numbers, including zero (0), positive (+) and negative (-) whole numbers.
Ask students to tell other real world uses for integers besides the thermometer.
Introduce a numberline; allow students to count in a positive, then in a negative direction starting at the origin zero (0).
Discuss with students the meaning of integers.
Locate a few integers on the numberline.
Emphasize positive and negative numbers.
Place a coordinate grid on the chalkboard.
Explain the coordinate plane, using the numberline as a basis.
Locate points on the coordinate plane first moving horizontally, then moving vertically.
Tell students the points found on the coordinates are called ordered pairs.
Use the game of tic-tac-toe four in a row to give students practice in locating coordinates using integers.

Conclusion:

Teams were chosen to play tic-tac-toe four in a row on the coordinate plane. Each team used a strategy to get four coordinates in a row either horizontally, vertically or diagonally. Team members located the ordered pairs successfully to win the game. The use of quadrants II, III and IV was encouraged.

References:

Heimer, Ralph T., Trueblood, Cecil R. **Strategies for Teaching Children Mathematics**. Addison Wesley Publishing Co., Reading, MA., 1977, pages 349-359.

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Fractions and Paper Folding

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Objectives:

The student will be able to develop the concept and properties of fractions using paper folding (origami).

Materials needed:

Each individual in a class should have the following:
1 ruler (in both english and metric units)
paper squares of varying sizes (at least 1 - 4 inch by 4 inch square)
1 sheet of directions

Strategy:

1. Taking the 4x4 square first, the student shall locate the midpoint of each side by folding the square in half. Next, fold in each of the corners of the square so that the vertices of the square meet in the center of the square.

2. Start a discussion about the new shape(s) by asking the following questions:
   1. What new shape(s) have been formed?
   2. How does the area of the new shape(s) compare to the area of the old shape?

3. Answering the first question, students may see triangles (the folded sides), squares (the final shape), and even other shapes depending upon the accuracy of the folds. The second question will show the relationship between the original shape and the new shape(s) formed. The students should be able to see that the four flaps cover the new square and, therefore, each flap is 1/4 of the new square. Also by either observation or by geometric proof, the students should be able to see that the new square has an area equal to half of the original square. Your level of vocabulary and mathematical concepts should be adjusted according to grade level.

4. Taking the vertex of the folded flap, fold the flap back so that the vertex now touches the midpoint of the outer edge of the new square.

5. Asking the same two questions you started with, start a new discussion. Students may see some new shapes, such as trapezoids, have now been added to the mix. Draw their attention to the new shape inside of the second square. Hopefully, they will now see a new, even smaller square. Have the students try to find the area of the smallest square. If they have trouble, show that four of the new little tabs formed by the last fold will cover the smallest square. Then demonstrate how many of these little tabs it takes to cover the second square (16). Therefore, the area of the smallest square must be 4/16 ths of the second square. Since four of the smaller tabs equal one of the larger tabs, 4/16 = 1/4 and the area of smallest square equals 1/4 th of the second square. You may choose to go further and demonstrate how the smallest square

is 1/8 th of the original square.

6. With an advanced group, you can even introduce irrationals by looking at the lengths of sides of the squares produced and using the Pythagorean theorem to determine their value.

7. Finally, fold the smallest tabs back under, producing a small picture frame which the students can now use to frame the picture of their choice. The above steps can be repeated with different sizes of squares to show that the above fractions (ratios) are constant and to produce different sizes of picture frames.

Performance Assessment:

K-3 Students will be able to fold any square piece of paper, following the instructions on the direction sheet, into a picture frame for the picture of their choice.
4-6 Students will be able to find the areas of the resulting figures created by the paper folding and determine what fractional part of the whole square is represented by the new sections created.
7-10 Students will be able to do all of the above plus name the shapes created and use the Pythagorean formula to find the dimensions of the new shapes.

References:

Sobel and Maletsky, **TEACHING MATHEMATICS:** A Sourcebook of Aids, Activities, **and Strategies**, Prentice Hall, 1988

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Number Up

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Objectives:

Using a deck of cards, the seventh and eighth grade student will be able to practice:

1. Addition, subtraction, multiplication and division of whole numbers.
2. Order of operations.

Materials needed:

Decks of cards with all face cards removed.
Chips of cards with ( ), +, -, *, / for the players to place between cards.

Strategy:

OBJECT OF THE GAME: To be the first player to use his/her 5 cards and the order of operations to attain the given value.

RULES:
1. No picture cards are used. Aces = 1. All other cards are face value.
2. To determine the dealer each player draws a card from the deck. High card determines the dealer. The dealer goes first and play proceeds to the left. The next deal also proceeds to the left.
3. The player with the most points wins. All winning hands must be proved verbally and visually.
4. Deal 5 cards to each player.
5. The dealer then places a card face up in the middle of the playing surface.
6. Each player may use any or all operations (addition, subtraction, multiplication, division). Parentheses can be used.
7. Using the 5 cards and the above operations, each player tries to attain the value of the card that was placed in the middle of the playing surface.
8. The first player to attain the desired value and state his/her equation and answer verbally wins 1 point.
9. The player(s) with the most points at the end of 5 games wins.

EXAMPLE: Desired value = 8 Cards dealt: 9,2,3,2,5
A winning combination: 2 * (2 * 3) + 5 - 9 = 8

Suggested variations: Use poker chips (blue, red, white) as points.
First person to attain the given value gets a blue chip, the second, a red and the third a white. You may give a value to each chip, blue being the highest, then red and white.

References:

It's In The Cards! Math Card Games Instruction Manual
Developed by: Diane P. Schiller, PhD, Deborah O'Connor, Catherine Thomas, Debra Ann Jagielski. Loyola University of Chicago, 1989.

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Math Game Using A Tic-Tac-Toe Board

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Objectives:

To introduce three mathematical operations -- addition, subtraction and multiplication -- by using Tic-Tac-Toe methodology

To introduce a new method in using the Tic-Tac-Toe grid.

To present a new method in problem solving.

Materials Needed:

Pencils
Overhead projector
Pieces of paper for computation
Handouts of sample math problems

Recommended Strategy:

The teacher will write some math problems on the board to be explained to the students.

Students will complete problems in computation on the Tic-Tac-Toe board or on paper. The student giving the first correct answer will get a point. The points will be totaled at the end of the game.

Place nine students in a square resembling a Tic-Tac-Toe board.

Scores will be kept on a Tic-Tac-Toe board by an "O" or an "X." The team scores by making a straight line of 3 O's or 3 X's.

The O's will compete against the X's.

If the answer is incorrect, the problem will go to the next team for a correct answer.

Players will rotate until all have had a chance to participate. Blank Tic-Tac-Toe symbols are given to students to create new problems.

The overhead projector will be used to introduce problems in finding the missing numbers. For example, a blank square in the Tic-Tac-Toe grid would require the answer 15 to the problem "How much is 3 times 5?" These problems will be shown one at a time to give students a chance to get the right answer or to ask questions about solving the problem.

Conclusion:

Students were introduced to Tic-Tac-Toe problems in addition, subtraction and multiplication and in finding the missing number.

Reference:

Family Math by Leon Kerr Sternmark, Virginia Thompson, and Ruth.

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The Moebius Strip

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Objective:

To investigate mathematical patterns using the Moebius Strip.

Materials Needed:

Strips of paper 10 inches long and 2 inches wide. Adding machine tape, construction paper or graph paper. Allow 10 strips for each student. Markers or colored pencils optional. Students will also need Scotch "Magic" tape and scissors.

Strategy:

Students are asked to examine their strips of paper to determine that each strip has two edges and two sides. Students are told to make a loop, turn one end over (in a half-twist) and tape the ends together. Make a second loop without twisting.

Students are asked to draw a lengthwise line in the center of each strip, continuing until they reach their starting point. Students will report all of their observations.

Students will note that their pencils never crossed over the edge. This surface does not have a top and a bottom or a front and a back. Instruct students to cut the Moebius strip along the line they drew. Ask students, "What did you get, how many sides does it have, how many half-twists does it have?"

Students are asked to make another Moebius strip and cut along a path that is about one-third of the distance from one edge to the other. Describe the results. Other Moebius strips may be constructed in the same way, cutting one-fourth of the way in and cutting one-sixth of the way in. Students are asked to describe their results after cutting each strip.

Students are encouraged to investigate strips with different numbers of half-twists, cutting each strip down the middle as they did with the first Moebius strip.

Make a Moebius strip and draw lines to divide it in thirds lengthwise. Shade the middle third. Cut along the edge of the shaded third. Describe your results.

Conclusion:

The Moebius Strip is an interesting topological figure. The investigation also provides a good exercise in having students derive a generalization from their empirical observations.

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Fraperdec*

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Objectives:

To enrich and further develop skills in conversion and sequencing of fractions, decimals and percentages, both in each individual set and in cross sets.

Materials Needed:

55 blank playing cards or oak tag cut to size
3 fine tip markers (different colors)

Strategy:

1 Divide cards into 4 stacks: 25 cards, 14 cards, 14 cards, 2 cards.
2 For the stack of 25, mark each card in the way playing cards are marked for each family of the following fractions using one of the markers:
1, 2, 3, 4, 5, 10.
Example: 4 family: **1**, **2**, **3**, **4** over 4 4 4 4   5 family **1**, **2**, **3**, **4**, **5** over 5 5 5 5 5
You should have all 25 card marked. Remember, 1 family member per card.
3 Take a stack of 14 cards and, using another color of marker, mark the cards like playing cards for the following decimals:
.1, .2, .25, .3, .33, .4, .5, .6, .66, .7, .75, .8, .9, 1.0
4 Take the last stack of cards and using the third color of marker, mark the cards like playing cards for the following percentages:
10%, 20%, 25%, 30%, 33 1/3%, 40%, 50%, 60%, 66 2/3%, 70%, 75%, 80%, 90%, 100%.
5 Mark the last 2 cards FRAPERDEC using all 3 markers. These are wild cards.
6 **RULES**
- a This game is for two to four players
- b "Dealer" will shuffle and deal out cards to players. Each player should have 5 cards. Remaining cards are placed face down in the middle of the playing area in a stack. Play starts to the left of the dealer.
- c First player picks top card. If it is useful to the player, he keeps it and tosses one he doesn't need face up on the playing area.
- d The next player picks a card either from the top of the deck or may pick up the card tossed away by the previous player if he can use it. This player then tosses away a card and so the game continues.
- e The first player, on HIS TURN, to have all 5 cards in equivalents or sequenced wins.

WINNING HANDS
- a PAIR Two equivalents in a set or cross set (2 equiv. frac., dec., per. same set or mix 'n' match. Ex.: 1/2, 2/4 same....1/2, 50% mix)
- b TRIO Three equivalents OR sequences in a set or mix 'n' match. Ex.: 1/4, 2/4, 3/4 OR 1/4, 50%, .75 OR 4/10, 2/5, 40%. The possibilities are numerous!
- c HIGH All five cards are equivalent or sequenced.

POINTS

PAIR 10 pts
TRIO 20 pts
HIGH 50 pts

PLAYERS left holding cards receive only half of point value for pairs or trios left in the hand. Unmatched cards are -5 points each.

DEFINITIONS:

SET: Number family, i.e., fraction family, decimal family, percentage family.
CROSS SET: Mixed families.
EQUIVALENTS: Members of different families and/or family members having equal values.
SEQUENCE: Ordered numbers whether from differing families or family members.

Conclusion:

As students become proficient at playing this game they find that their mental ability to convert and sequence fractions, decimals and percentages, either in sets or cross sets is speedy and correct.

INSTRUCTION SHEETS FOR TWO MORE COMPLEX VERSIONS OF THIS GAME ALSO AVAILABLE: SUPER FRAPERDEC and SUPER DUPER FRAPERDEC.

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How To Use An Abacus

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Objectives:

The students will be able to:

1. Demonstrate the properties and operations of a number system
2. Develop an understanding of the commutative, associative and distributive properties of the mechanics of the abacus
3. To understand the place value of whole numbers using an abacus

Materials:

Chinese Abacus (Suan Pan or Soo Pain)

Strategy:

A typical Chinese abacus consists of columns of beads. A crossbar separates the beads. Each column has two beads above the crossbar and five beads below it. Each upper bead represents five units and each lower bead equals one unit.

The first column on the right is the ones' column; the second column is the tens' column; the third column is the hundreds'; the fourth column is the thousands'; and so on. The ones' column represents numbers from one to nine. Each bead below the crossbar has a value of one (1) and each bead above the crossbar has a value of five ones (5). The tens' column represents numbers from 10 to 90. Each bead below the crossbar has a value of ten (10). The beads above the crossbar has a value of fifty (50). The hundreds' column represents numbers from 100 to 900. Each lower bead equals 1 hundred (100) and each upper bead equals 5 hundred (500).

To place a number on the abacus, move beads to the crossbar. When beads are moved away from the crossbar, they are cancelled. This means a lower bead is cancelled when it is lowered from the crossbar and an upper bead is cancelled when it is raised from the crossbar.

To place the number 3,684 on the abacus, raise 3 of the lower beads in the thousands' column. Then lower one upper bead and raise one lower bead in the hundreds' column to represent 6 hundreds. Next, lower one upper bead and raise three lower beads in the tens' column to show the 8 tens. Finally, in the ones' column, raise four lower beads for the 4 ones. Now the abacus shows 3,684.

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A FIBONACCI PRIMER

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Objectives

1) To share knowledge about an interesting but obscure facet of recreational mathematics which is accessable and interesting to junior and senior HS math students.

2) To challenge teachers and students alike to discover and perhaps prove many interesting properties of the Fibonacci sequence and its unexpected relationship with the geometry of the regular pentagon and with the theory of limits.

Equipment and Materials

Writing implements; hand calculator (scientific preferred); accurate millimeter scale.

Teacher-prepared worksheets to calculate and display up to twenty elements of the classical Fibonacci Sequence ("CF") and several varieties of generalized Fibonacci-like sequences ("GS").

Teacher-prepared worksheets with several regular pentagons -- complete with all diagonals -- and with all vertices and intersections of diagonals labeled.

Recommended Strategies

Provide a **brief** explanation of who Leonardo of Pisa was, his dates and place in math history -- the rabbit problem is optional. Use proper terminology which means subscripting: We denote specific terms of GS with subscripts. The i-th term of CF is written as F_i. In CF, the first two terms are always $F_1 = 1$, $F_2 = 1$.

The basic rule for any Fibonacci or Fibonacci-like sequence is that every term is the sum of the two previous terms. In our symbols, $F_{i+2} = F_i + F_{i+1}$, is an element of the set of positive whole numbers: 1, 2, 3, ... The ith term of CF is abbreviated as F_i; the first term of CF is F_1. The expression "F_{n+3}" means the "n + 3rd" term of the F-sequence.

The Fibonacci sequence and its properties are generally considered part of recreational mathematics, a category of math generally ignored by the math "establishment." **But** teachers know that play ought to precede serious study; so this is perhaps a powerful reason to include F in our teaching! It is rich in non-trivial arithmetic practice, calculator practice and problems, and in algebraic applications. Fibonacci connects with Geometry -- even Pythagorean Triples -- and probability. The ratios of successive terms of F dramatically illustrate oscillating series and the question of convergence of infinite series (calculus).

On the worksheet with the regular pentagons, carefully draw the diagonals with a sharp pencil. Measure lengths of sides, diagonals and segments of diagonals to the nearest millimeter. Keep a neat record of your measurements. Check your results against GS or CF. If they don't fit, can you devise a way to make them fit? Compute ratios of consecutive lengths, larger to smaller. What can be discovered here?

Thought Starters on Fibonacci

Write the first twenty terms of CF. Here are some questions to answer as you scan this list:

1) Are odd or even terms more numerous? What **is** the ratio of odd to even terms? Will this continue forever? Why?

2) F_{12} = 144 and 144 = 12^2. There are no other perfect squares among the Fibonaccis, but this wasn't proved until 1963. Can you find a perfect number or two among the F's?

3) Add the first n F_i's. What is special about the sum? Is **it** a member of F? Where is it? What should the formula be?

4) If I want to know the value of a large F_i such as F_{307}, is there a shortcut or **must** I list all 306 terms of F? There is a shortcut -- get your calculator out:

Let x = 0.5 + 0.5 sqrt 5 and y = 0.5 - 0.5 sqrt5

Then $F_n = (x^n - y^n)$/sqrt 5 "sqrt" = "square root of"

5) What is the sum of the first n **odd** F_i? Proof (not hard).....

6) Examine your answer to (1). Recompute your list of F_i using different values for F_1 and F_2. What do you now find for the ratio of odds to evens? Is there a general rule working here? State it.

7) Divide F_{i+1} by F_i for every entry in your list of F_i. As i increases, what happens to the sequence of quotients? Try this for another FS (one with different first and second terms). Compare your result with the famed "golden ratio."

8) Can you "massage" the Pascal Triangle and get the Fibonacci Sequence out of it? Now we can expect a relationship between Fibonacci, binomial coefficients and probability theory!!!

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Those who would like a list of readings/references on this fascinating topic are invited to contact me for one. Non illegitimus carborundum, y'all.

{Dedicated to Roy and Dianne Coleman by a stubborn, reluctant student.}

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Geometric designs in the game of "Life".

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Objective:

To predict and discover patterns generated in the game of "Life".

Apparatus Needed

Large checkerboards (one per two students) and flat counters or checkers of three different colors.

Recommended Strategy:

The game of "Life" is a fantastic solitaire pastime because of its analogy to the rise, fall and alteration of societies of living organisms. The dramatic patterns can be seen using a computer. The game was invented by John Conway, a University of Cambridge mathematician, in 1967.

To play the game, start with a configuration of counters near the center of the board. The rules of the games are as follows: (1) **Survivals**: every counter with two or three neighbors survives for the next generation. (2)**Deaths**: Each counter with four or more neighbors dies (is removed) from overpopulation. Every counter with one neighbor or none dies from isolation. (3)**Births**: Every empty cell adjacent to exactly three neighbors- no more, no fewer - is a birth cell. A counter is placed on it for the next generation.

The following procedure can be use to play the game. (1) Start with a pattern of white counters. (2) Locate all counters that will die. Place a red counter on top of each one. (3) Locate all vacant cells where a birth will occur. (It is important to understand that births and deaths occur simultaneously and only white counters contribute to births). Place a blue counter on each birth cell. Next remove all deaths (piles of two) and replace blue counters with white "adult" counters. This is the next generation.

One must be very careful in checking for births and deaths; mistakes are easy to make. Start with all possible arrangements of three counters. (There are five distinct ways.) Some patterns die out in a few generations, while some become stable- no births or deaths- while some simple patterns go on for several hundred generations before dying or becoming stable.

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Paper Pool

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Objectives:

Students will: recognize rectangles whose sides have the same ratio; use the concept of common factor to find rectangles with the smallest area having a given ratio of sides; practice organizing data and looking for patterns; use the concept of common factor and a parity check to predict the behavior of a ball on a pool table; final corner; number of hits.

Apparatus Needed:

Students will need a ruler or straight edge and a pencil for this activity. Worksheets used in this activity are taken from the Middle School Math Project, "The Mouse and the Elephant" book, published by Addison-Wesley Publishing Company, 1986. Paper Pool is an application of many concepts: factors, multiples, rectangles and the relationship of being relatively prime. Before seeing how to apply these concepts, students must gather and organize data, then search for patterns.

Recommended Strategy:

Paper Pool is played with an imaginary ball being hit from the lower left-hand corner marked A, at a 45 degree angle. A ball hit in this way will bounce off the sides at a 45 degree angle. Also, if a grid is placed on the table, the ball always traverses on diagonals of the squares of the grid. Students first learn how to predict the pocket into which a ball will fall and the number of hits as the ball crosses the table. Students further develop their analytical skills by investigating the number of squares crossed. All three relations depend upon the lengths of the sides of the pool tables.

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Graphing Game

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Objective:

To introduce the graphing of ordered pairs on the cartesian plane.

Materials:

A cartesian graph that goes from -4 to 4 on both axes. The axes should be **thick** lines with arrows facing in the positive direction. The other lines on the graph should be lighter than the axes. Horizontal lines should be a different color than the vertical lines, but it is not necessary. **Do not label anything.** No X-axis, no Y-axis, no numbers on the axes.

Strategy:

Divide the class in teams (if possible no more than 4 teams with no more than 7 students per team). Assuming that you have 4 teams, take 4 sheets of paper write the group symbol assigned to each team on top of their paper and ask them to list the names of their team on that paper. You may want to use X, O, /\, #, for the four different symbols. After the students have written their names on their team paper, collect the papers, write the 4 symbols on the board and list the members of each team under their symbol. Leave enough space between the team columns on the board so that you can insert checks to keep track of who is up next when you play the game. **Directions to students:** The object of this game is to get four of your symbols in a row, (next to each other) horizontally, vertically, or diagonally. At the same time you may wish to prevent the other teams from getting four of their symbols in a row. All teams start off with 20 points. When a team gets four in a row, 4 points are added to its score, but the other three teams get one point subtracted from their score. To get your symbol on the graph choose a pair of numbers from the set that is on the board {-4,-3,-2,-1, 0, 1, 2, 3, 4, }. You may use any pair of numbers from this set including using the same number twice. Once I call on you and you give me a pair of numbers, **you must watch how I move on the graph. I will not explain.** Once you give me both numbers of the pair you cannot change your mind, but it's O.K. to change your mind after saying the first number. If the point described by the pair of numbers that you give me is already occupied, you lose your turn. Remember, the pair of numbers that you give me are directions on how to move and I will follow those directions. Team members may help each other, but only the person that I call on can give me the pair of numbers. You cannot tell another team what to do. Teams and/or individuals will have points taken off if they don't play by the rules. Further directions to the teacher: Put a check on the board after the student's name once they have taken their turn. Since the number of students on each team will not always be the same, it will help you keep track of who is next on that team when it is that team's turn to play again. Two possible ways to end the game:

A) Once a team has four symbols in a row erase everything and start over.

B) Once a team has 4 symbols in a row erase only those four symbols and continue playing the game.

Either way the game will end when the bell rings.

There are several variations of this game and you may wish to develop your own.

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Geometric Bingo

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Objectives:

Learners in grades 7-10 will be able to name and identify the names of 20 geometric shapes.

Students will derive the properties of various geometric figures as questions are formulated to distinguish the shapes.

Apparatus Needed:

Geometric Bingo game card, envelope of geometric chips for each player. Overhead projector and transparent game card with transparent chips. Teacher must prepare game materials as follows: Game cards can be made from construction paper and can be laminated for repeated use. Each board should be 5x5, or contain 25 one-inch square spaces. Label the four corners on the board "FREE"and add one of the following terms under the word "FREE": point, line, line segment, and ray. Cut at least twenty-one two centimeter square chips for each student and place these in envelopes for them. Each chip should have a picture of one of the two-dimensional geometric shapes commonly called a plane. Consult the glossary of any geometry textbook for a list of terms for geometric figures.

Recommended Strategy:

Supply one game card for each player. Each card should have twenty-one spaces or places with the geometric names that correspond to each of the chips in the envelope. Names should be typed onto adhesive labels and entered onto the game board in a random fashion.

Prepare an overhead transparency of the game card and chips for purposes of explanation, discussion and calling the game.

Directions: Introduce this activity by treating the entire class as the opponent. Use the transparency on the overhead projection as the display board. Students work individually or as teams. Teacher explains that the FREE space names--"point","ray","line","line segment"--are givens which help us understand the descriptions of the twenty shapes that make up the game. Players should then be directed to look at the center FREE space and instructed to take the chip from their envelopes that has the stick-on tag. Players earn this center FREE by writing a description of their body size or dimension. The student chooses a term from an arbitrary list of personal sizes that can be written on the chalk-board,i.e., compact, midsize, fullsize, sleek; or, obelisk, rotund, statuesque, etc. Student selects and writes his/her body type on the tagged chip and attaches it to the back of the game board over the center FREE space. This part of the introduction is mainly motivational; thus, it is optional. The game proceeds as follows:

l. Caller draws a figure from the envelope containing the cut-up game chips and matches it with the form on the display board. Students are then encouraged to pronounce the name of the shape, locate the figure among their game pieces, and place it in the appropriate place on the board.

2. The goal is to have players formulate a series of questions or opinions regarding properties of the figures as they attempt to bingo.

3. Examples of valid questions are as follows:
"Is your figure a plane?"
"Does your figure have diagonals?"
"Is this figure a basic Sesame Street shape?"
"Does this figure contain one pair of parallel sides?"

Scoring: Players win by getting bingo horizontally, vertically, or diagonally. Players game chips may be left on the board after each game until all shapes have been called on the display board.

Conclusion: As students play "Geometric Bingo" they are actively thinking about the commonalities and differences exhibited by the figures and the strategical value of the questions they ask. The game can be modified to include various skills throughout a geometry course.

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Mathematics/Physics

What Does Greatest Common Factor Mean to Me?

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Objective(s):

What are the factors of a given integer.

Materials:

Materials for four groups

- Four 250ml graduated cylinders, four 100ml graduated cylinders, six containers of different size with pre-marked volume on each of them.

Strategy:

The teacher will first show the concept of factors through **modeling**. Then the students will do an activity that will help them understand further the concept of common factors and greatest common factor.

Modeling by teacher

(1) Choose a pre-marked container and tell students the objective is to fill the container with water up **exactly** to the mark by using a graduated cylinder. However, the cylinder must carry the same amount of water, the “basic unit,” each time water is added.

For example, if the volume of the container is 300ml, a “based unit” of either 20ml, 30ml, 40ml, and so on, can be used to see which one can **exactly** fill up 300ml of water into the container (Choose a few volunteers to fill up the same container with different “basic units”).

(2) Ask students why not all “basic units” being chosen can be used to fill the container **exactly** up to the mark. Explain the concept of factors after the discussion.

Student Activity

(1) Each group will use the cylinders being provided to fill a container up with water by choosing a “basic unit” they believe that can carry out the task.

(2) Record the "based unit" being used and fill out the related information in the following table.

(3) Repeat step (1) and (2) for 5 trials.

Volume in ml.	"Basic unit" in ml.	Number of repetitions	(Exact?) Success / failure
Container #1 Volume =			
Container #2 Volume =			
Container #3 Volume =			
Container #4 Volume =			
Container #5 Volume =			

Performance Assessment:

(1) What is the most efficient way to do this activity?

(2) In what way does it make a difference?

Through the discussion of the above questions, students will find out and understand the concept of common factors and greatest common factor.

Conclusions:

The concept of greatest common factor is a useful tool in some real life applications. For example, if the above activity turns into a competition, those who know the concept of greatest common factor will have a better chance to win the contest. Another example can be such as what is the most efficient way to give an exact change of 50 cents? Two quarters? Five dimes? Ten nickels? Or so forth.

Winnie Koo - Ravenswood School

Learning with Links

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Objective(s):

Discuss and demonstrate the meaning of counting, measuring, and estimating of objects.

Materials Needed:

Four boxes of plastic links of different colors.

Strategy:

Using handson activities to help students understand the concept of counting, measuring, and estimating.

Activity of Counting

(1) Explain and demonstrate the meaning of "counting" (write the word "counting" on the board) using example such as money, fingers, or furniture inside the classroom, etc.

(2) Show students what a link is (write down the word "link" on the board) and ask a few students to come up counting certain amount of links on the tables to see if the students know how to count. For example, ask the students to count 5 links, 10 links, 15 links, and so forth.

(3) Ask students if they still have any question on how to count. If they still have question, repeat step 1 and 2 with different examples until they all understand the concept of counting.

Activity of Measurement

(1) Separate students into groups and distribute a box of links for each group.

(2) Demonstrate to students how to put the links together to form a longer link.

(3) Ask each group to form links of different number such as links of 5, 7, 10, and so forth, to see if they have any trouble in doing it.

(4) Tell students we can use these links for "measurement" (Write the work "measurement" on the board) and tell them the word "measurement" means how long or how wide something is. Show students some examples until they understand the meaning of measurement.

(5) Distribute the handout to each group.

(6) Ask each group to turn to page 1 of the handout and ask who can tell what is going on in the first picture (listen to the response, give praises to those whose answers are correct).

(7) Tell students the name of the boy in the picture is Julio and Julio's arm is 12 links long. Have students construct a length of 12 links to see how long is Julio's arm.

(8) Repeat step 7 with the rest of the picture on page 1 and 2.

(9) Now ask students of each group to measure two of their body parts and to put down the data on the sheet, including a picture of the body part they measure.

(10) Pick some students to report the result.

Activity of Estimation

(1) Write down the word "estimation" on the board and tell students the next activity is about estimation. Tell students that we can also measure things in a different way called estimation. But estimation is different in a way that it does not tell the exact measurement of a thing. What it means is that estimation is a way to guess how long or how much is a thing.

(2) Ask for a volunteer.

(3) Take out a pen or a pencil. Ask the student how many links does it take to find out the length of the pen or pencil.

(4) After the student gave the answer, ask him or her use the links to find out the exact length of it. Then ask the student how many link(s) of his/her answer is/are off from the actual answer. The student's answer should be closed to the exact answer. This example tells what it means by estimation.

(5) Do the estimation activity on the handout.

Performance Assessment:

Through the activities and by working on the work papers, students will be assessed how much they have learned from the lesson.

Conclusions:

Students should have a solid understand of the concept of counting, measuring, and estimating.

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Mattie Drane - Crown Academy School

Fractions

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Objective(s):

Identify the numerator and denominator of a fraction. (Grade 1-4)

Materials Needed:

Crayons or markers, construction paper, Dominoes, M&M Candy, fruits, toothpicks, large bowl, paper cups, papers, pencils, paper towels, plastic knife

Strategy:1 Emphasize that the down number, (denominator) tells how many fair shares are in the whole object and that the top number, (numerator) tells how many of the shares are being talked about.

Strategy:2 First have each student study a blank sheet of paper. Ask, "How many folds have you made?" Next have each student fold his/her paper in half, then unfold it. Ask students how many folds they made, how many fair shares they have and what each fair share is called. Have students write 1/2 on each fair share. Then have each student fold a second sheet of paper twice to create four equal shares. Prompt students to tell that they made two folds and have four fair shares that are each called one-fourth. Then give students oral directions for coloring their papers such as "Color one-fourth red, two-fourths blue, and one-fourth yellow." If desired, have students turn these papers over and repeat the sequence, this time create your own fair shares.

Strategy:3 Give each of several small student groups a handful of dominoes. Explain that each domino features a set of dots that has been divided into two parts. Instruct each student to draw each of his/her group's dominoes on a sheet of drawing paper. (Students can trace the domino shapes, then draw the dots.) Below each domino, have each student write the two fractions that describe the domino's dot arrangements. If desired, challenge students to add each pair of fractions-to make a whole!

Strategy:4 Give each student 12 M&M candies. Have each student identify the fractional part of his/her set represented by each color of candy. To extend the lesson, have students eat a portion of their candies, then repeat the activity using their net sets.

Strategy:5 Have each student bring one fruit item to school. While students observe, cut each piece of fruit into fractional parts. For example, an apple could be cut into halves, quarters, and eighths. Or a banana could be cut into thirds, sixths, and twelfths. Have students identify the fractional parts as they are formed. Mix the fruit pieces together in a large bowl; then serve the fruit salad in paper cups. Have students use toothpicks as their eating utensils.

Performance Assessment:

1. Questions & answers
2. Teacher observation
3. Students will create their fair shares

Conclusions:

80% of the students received basic knowledge of fractions.

References:

Mrs. Mattie Drane, Book of Math Early Education Students '99.

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Mathematics/Physics

Data Collection -Primary Poster

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Objective(s):

Students will learn how to collect, graph and analyze data.

Materials Needed:

pencils, markers or crayons, chart paper, scratch paper

Strategy:

Students will take their scratch paper and select a question that they are interested in finding information about, such as *What is your favorite food?* Then students choose three items that their classmates will have to choose from; for example, *1)pizza, 2) hot dog, 3) nachos*. With some instruction on data collection, students in groups, survey the other students on their question using tally marks. After students have collected their data, students take the chart paper and fold it into four equal parts. At the top of the paper, the students turn their question into an incomplete sentence. For example, *My favorite food is…* On the top, left fourth of the paper, the student draws the three items. The top, right fourth, the student has a small chart with each item listed with the tally marks beside them under the appropriate category. You might want to have a preprinted chart ready. The bottom, left side of the paper will contain an actual line graph. You might want to have this graph preprinted especially for the younger children. The last area of the poster becomes five questions that the students create by observing his/her collected data. For example, *How many students liked nachos?* or *How many more students liked pizza than hot dogs?* The questions are not to be answered.

Project Extension: After the projects are completed, students might exchange their posters with their classmates to be answered.

Generic Example Of Primary Poster:

Title...	
Three Pictures of Selected Items	Chart with Tally Marks From Survey

Line Graph	Five Student Generated Questions

Performance Assessment:

The final poster/presentation should display four skilled areas. For each correct section, the student should receive 25 points for each section.

Project Extension: Each question answered correctly should receive 20 points.

References:

The Teachers Academy of Arts and Sciences Presentation, 1994.

Mathematics/Physics

How do You Stack Up? Revisited

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Objective(s):

- Students will estimate the number of pennies, nickels, dimes and quarters in plastic bags.
- Students will build stacks of each type of coin.
- Students will find the thickness of a penny, nickel, dime and quarter after measuring their stacks.
- Students will measure to the nearest millimeter using a ruler.
- Students will determine how many coins of each type will fit in tubes of different lengths.

Materials Needed:

Approximately 100 of each type of coin, quarter, nickel, dime and penny. (Save up your pocket change for about 3 months and it should be enough.)
4 large plastic bags to put the coins in
4 different size tubes to fit each type of coin
Calculators
Chalk
Rulers

Strategy:

As a an introductory activity, keep the coins in the plastic bags spread out and have the class guess which bag has the most coins. (You will have counted the coins already so you know the answer.) Give the student with the correct answer a small prize such as a Susan B. Anthony dollar coin.

Next, divide the class into four groups – call them the pennies, nickels, dimes, and quarters groups. Have each group stack their coins in piles so they can measure the height of each pile. After they measure each pile, have them record the height of each pile and how many of each coin are in the pile on the board. Then ask "How can we find the thickness of just one of each of these coins?" The students should answer "Divide the height of the stack by the number of coins." Have them do the calculations and then record the thickness of each coin on the board and compare answers. If there is a large discrepancy in the answers, an error in measurement or in calculation could have occurred. Ask them to compare their answers to the government determined thickness published by our government and printed here:

Penny 1.57 mm
Nickel 1.98 mm
Dime 1.35 mm
Quarter 1.75 mm

Have them find the average of their calculated thickness values for each kind of coin for the final activity. Collect the bags of coins from the students. Then, pass out a tube to each group. Using a ruler and a calculator only, each group should tell you how many coins are needed to fill the tube. After they tell you their calculated answer, give them that number of actual of coins to see if their answers agree. If they do match, great! If they do not, perhaps an error was made. If the difference is only 1 or 2 coins, that is okay too.

Performance Assessment:

A wonderful way to assess the students' understanding of this concept is to ask them to imagine a stack of coins $1000 high. How many nickels, pennies quarters, and dimes would that be? How tall would each stack be in mm, cm and m? Then give the following statistics as a comparison: a basketball player is 2m tall, the ceiling of most buildings is 4m, the height of a ten story building is 40m, and the height of Sears Tower is 440m. How tall would each of these things be in nickels, dimes, quarters, and pennies?

References:

Page, David and Philip Wagreich. Manuevers with Nickels and Numbers. Dale Seymour Publications, 1990.

Mathematics/Physics

Measuring for Cookies

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Objective(s):

- The students will measure ingredients using standard and metric measuring utensils.
- The students will read envelope contents and follow directions in sequential order.
- The students will make a batch of chocolate chip cookies.

Materials Needed:

Sanitizing wash	Measuring cups and spoons (Standard and metric)
Towel	Cooling rack
Apron	Toaster oven
Hair net	Mixer
Mixing bowls	Baking sheet
Spatula	Timer
Spoons	Pot Holder

Ingredients:

Baking soda	Brown sugar
Butter	Chocolate chip morsels
Flour	Salt
Shortening	Sugar
Vanilla flavoring	

Strategy:

The class will divide into two groups. Each group will choose a leader, who will be the only person allowed to communicate with the teacher. This usually encourages students to work together and to try different ways to complete their tasks. The teacher informs the class that each group will be making a batch of chocolate chip cookies. The teacher stresses the importance of good hygiene and sanitation, and makes sure that each student washes his/her hands. *(All ingredients, toaster oven, timer, and cooking/baking utensils are assembled and laid out on a table.)* The group leaders will receive a packet containing labeled envelopes that identify the ingredients and the amounts to be measured out. Each group will receive instructions that outline the sequence in which the measured ingredients are combined and who should actually do the mixing, baking, etc. The leader will have the only copy of the complete recipe. The leader will then distribute the envelopes to the group members and observe to make sure they are following the directions given. (Group A will use the standard measurements and group B will use the metric measurements.)

Performance Assessment:

This activity is being conducted in a way to help students to see clearly the importance of making accurate measurements and following directions. Once students determine that cookies are being made, this motivates the students and they usually will verify the accurate measurement of ingredients by other group members. After the cookies bake, the teacher will examine the cookies for texture, size, shape, crispness, softness, etc. This will lead into a discussion in which the students estimate what caused the cookie to be soft, crisp, etc. The students will also engage in a discussion in which they would identify the measuring utensil used and explain the importance of accurate measuring, estimating, and following directions. I would also have the students to complete an observation sheet on this lab experience and identify alternate measuring utensils they could substitute. While the cookies were baking, we would discuss the measuring utensils used for particular ingredients and reducing or increasing recipes.

References:

Brooks, Janus, Measuring for Cooking, 1986.

Medvel, Eva, The World of Food, Prentice Hall 1990.

The Southern Living Cookbook – Recipe.

Ratio, Percent & Proportions

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Objectives:

To write fractions as percents for seventh graders.
To find the percent of a number.
To find percents using proportions.
To calculate the weight of objects (beads) in grams given specific percents.
To verify the weight of objects (beads) on a scale in grams in cooperative learning groups.

Materials Needed:

calculators
electronic scale measures in grams and ounces
clear plastic liter bottle
clear containers for each cooperative learning group
multi-colored chalk or overhead transparency markers
containers to hold objects
beads of various colors

Strategy:

"The phenomenological approach to mathematical instruction asks a question which requires the use of mathematics to answer it. The question must be based on a physical entity present for observation and use the mathematical processes you are teaching at the time. The answer to the question must be verifiable by direct observation."

How much will the beads that each person has weigh? Four cooperative group members are sitting around a pile of beads weighing 237 ounces. The first person takes 4 beads from the pile, the second person takes 3 beads, the third person takes 2 beads; the fourth person takes 1 bead from the pile. They continue the process until all the beads are gone. Each person now holds a percent (10%, 20%, 30% or 40%) of the original pile.

Each cooperative math group will do their calculations first.

The total weight of all the beads is 237 grams. The first student should have 130 grams. 40% of 237 is 130.00 grams. The second person should have 30% of 237 grams or 71.10 grams. The third person should have 30% of 237 grams or 47.4 grams. The fourth person should have 23.7 grams or 10% of 237 grams.

Check each individual's calculations.
Verify each individual's beads weight on the electronic scale.

Performance Assessment:

Give the cooperative math groups different bags of beads to calculate weight with the same percentages 40%, 30%, 20%,10% or, give them new percentages to investigate.

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MISSION: POSSIBLE

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Objectives:

- **Grades 5-8**
- Students will covert scaled directions in inches to actual measurements in feet.
- Students will correctly measure distances on an outdoor path.
- Students will enlarge a section of a map 5:1.

Materials Needed:

- scaled directions (one set per group)
- calculators (one per group)
- tape measures (one per group)
- "microchips" (one per group)
- map of IIT campus (one per group)
- 8 1/2 x 11 paper (one sheet per group)
- rulers (one per group)
- colored pencils

Strategy:

Divide students into groups of four or five.

Tell students they are on a **mission**: In order to be hired as spies for an upcoming project, they must successfully complete the following task before it self-destructs in 50 minutes!

1. Students are given four directions scaled in inches.
2. Students convert these directions into actual measurements by using proportions.
3. Students measure the actual distances on an outside path that leads to a hidden "microchip".
4. Students exchange their "microchip" for a map of the IIT campus.
5. Students enlarge a section of the map 5:1.
6. Students plot their path on the enlarged map.

Performance Assessment:

Students enlarge a section of an IIT map 5:1, and then plot their path taken to find the "microchip".

Students compare their maps to a master map, and are graded according to accuracy.

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Dream Home Mathematics

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Objectives:

This lesson-game is designed for grade levels 5-12.
Students should be able to:

* Use basic math to determine affordability of a home based on a given income.
* Add, subtract, multiply, and divide, as required.
* Calculate decimal placement for currency, percentages and interest.
* Use a calculator.
* Estimate affordability based on income, prior to computation.
* Investigate different careers and their salary ranges.
* Understand and calculate percentage, interest rates.
* Understand gross income.
* Calculate and understand taxes, withholdings and deductions.
* Calculate net income.
* Understand and compute the expense and cost concept.

Materials:

* Careers catalog/magazine with salaries
* Copies of newspaper classified section
* Calculators
* Pencil/pen
* Construction paper (approx. 11 X 12)
* Play money (optional for variation with banker)
* House plans with price (magazine's with house plans or create your own)
* Glue
* Scissors
* 3" x 5" index cards

Recommended Strategy:

* Review lessons on computing percentages, interest, decimals and division.
* Review a range of home prices and designs.
* Review/teach the use of a calculator to compute interest, percentages, add, multiply, divide and subtract taxes, deductions, and expenses.
* Skipping one space, number ten 3 x 5 cards 1 to 3. Head the card "**CAREERS**. Use the following format:

```
|             CAREERS              |
|                                  |
|1. Career:  Doctor                |
|                                  |  3 x 5 card
|2. Annual Salary:  $250,000.00    |
|                                  |
|3. Added Expenses: Child support  |
| $1,000 or Child's College payment|
| $2,700 per month (add to F)      |
```

  Career card info may be obtained from a "Careers" catalog/magazine or create your own (keep it realistic). Create real life "added expenses" =< $5,000 per month.
* Using any magazine, newspaper or both, the teacher or students cut out various

home plans (preferably with a picture) and glue each one to a sheet of construction paper, numbering each and giving it a bold heading of "DREAM HOME". Use the price listed in the newspaper, magazines or create your own. In bold numbers, at the bottom of the construction paper, place the price of the home. If you create your own, be realistic.

* Collect the career cards and the dream home sheets (in 2 stacks).
* Distribute one career card and one dream home sheet to each group.
* Create a data collection sheet in the following manner and order:

DREAM HOME MATH DATA COLLECTION: Can I afford to buy this home?

What is your occupation and annual salary?________________________________
Compute your monthly income (x/12) A.______________
What is the cost of your home on "DREAM HOME CARD"? (y) B.______________
Compute tax & payroll deductions (33% of A.) C.______________
Compute loan payment (mortgage) & interest (9% of y)/12 D.______________
Compute monthly property tax (10% of y)/12 E.______________
Utilities, car payment, food & one child is your fixed monthly expense of $1,000 plus (+) the added expense from your career card F.______________
Compute total debt by adding lines C. and F. G.______________
Subtract line G. from line A. for net income H.______________
Add lines D. and E. for total home/mortgage cost I.______________
Subtract line I. from line H. for cash remainder (+/-) J.______________

If line J. has a positive(+) cash remainder, congratulations, you can afford to buy the home, go to the banker or loan officer for amount shown on line B. Each month you must pay the bank/loan company amount shown on line I.

If line J. has a negative(-) cash remainder, I'm sorry, the home you have selected cost too much for the amount of net income you have after subtracting your total debt on line G. You don't make enough money to buy this particular home and have such large debts. Try a less expensive home.

/ **=** Divide/Division
x **=** Annual Gross Salary/Income
y **=** Cost of Dream Home

* Compare and graph home cost to net income/salaries, expenses/debt between students.
* Explore various careers and their salary ranges to teach affordability.
* Explore difference between rentals and home purchases and how basic math is used to provide an answer for; "Can I Afford to buy this home?"

Performance Assessment:

Students should compare the cost of buying a home and renting. Math calculations on data collection sheet will be checked for accuracy. Students at a later lesson, use their parents income and rent/mortgage to determine homes they can afford.

Note:

Any variations to "DREAM HOME MATH" should consider age and grade level. and pictures if possible. This exercise reinforces five (5) primary math functions and introduces the student to one of the most valuable lessons of life, simplicity of math in buying a home.

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Temperature

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Objectives:

1. To read temperature on a Celsius thermometer

2. To read and interpret bar graphs

Materials Needed:

1. Celsius thermometers
2. art papers
3. pencils
4. scissors
5. seasonal clothing
6. cups
7. large container of ice
8. large container of hot water

Strategy:

Students will do a quick review on counting numbers by twos, and ordering numbers from least to greatest.

Instructor will lead a discussion on weather conditions for each season. Have the class make a list of words that describe these seasonal conditions. Examples include hot, cold, icy, mild, scorching, cool, chilly and so on.

Display the thermometer. Move the indicator to show room temperature. (20^oC), a winter day (0^oC).

Explain that a thermometer is similar to a vertical number line. Show that each mark on the thermometer stands for 2 degrees or counting by twos.

Point out different temperatures for each season. Summer 30^oC, Fall 12^oC, Winter 4^oC, and Spring 24^oC.

Have each group draw pictures of clothing they would wear if temperature were 35^oC, 14^oC, and 22^oC.

Review reading temperatures using the Celsius thermometer. Discuss week's temperatures.

Make a bar graph using the given temperatures for the past week.

Homework: collect the daily temperature reports from the newspaper or television.

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Sales Tax

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Objectives:

This lesson is design for grade level 6-8
Upon completion of the lesson, the students should be able to:
* Find out what percent of sales tax is changed when purchasing merchandise or food by dividing the price by the sales tax.
* Understand the differences of sales tax on merchandise and food.

Materials:

* Store catalogs (eg. J. C. Penny, Spiegel, Montgomery Wards, Sears, Venture, K Mart, Carson Pirie Scott.)
* Store Receipts
* A chart made out similar to a receipt: Titled in one column Items and in the other column Price. At the bottom Price column should be Subtotal, Tax and Total.

Recommended Strategy:

* Introduce to the students that they have a certain amount of items to to purchase 5-10 items.
* Explain to the class, they are given $500.00 to spend and the one who comes closet to spending $500.00 will receive a prize.
* Write down items, the page you picked the item from and write down the price. Be as specific as possible.
* Divide the class into groups of two or three. Each member will get to purchase at least $160.00 maximum. Out of the 5-10 items purchased, you must include a discount.
* Each group will be given a store name and their neighbor store will check for errors.
* After everything is checked the store that has an error will be given a consequence. The store who finds the error or that individual will be rewarded.

Performance Assessment:

Discuss with class the different taxes in each state (Wisconsin, Michigan, Ohio and Illinois). Observe the errors and prices of stores in each state and find which group came closet to $500.00 and issue out prizes. This project best used in the morning.

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Money Matters

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Objectives:

The goal of this lesson is to introduce the students to different countries' money and the United States monetary value of a penny, a nickel, a dime, and a quarter. This lesson can be used for primary and intermediate students.

Materials Needed:

-World Map
-Globe
-Play-Doh/Clay (4 different colors)
-Attri-Cubes
-Colored Markers/Crayons
-Legos
-Butcher Block Paper (white/brown)
-Plastic Clay Tools/Cookie Cutters
-Play Food (milk, eggs, beans, etc.)
-Building Blocks
-White/Manilla Construction Papers
-Styrofoam Trays (10)

Strategy:

Using the materials listed above, a marvelous dimension of the world of money can be revealed. Most of the time primary students lack an understanding of money and how it works. This lesson gives students a chance to recognize that there is very little that can be done without money.

Begin the lesson by writing the names of the following on the blackboard or an easel:

Algeria (Dinar)
Austria (Schilling)
India (rupee)
Italy (lira)
Spain (peseta)
United States (dollar)
Argentina (Peso)
France (franc)
Israel (pound)
Japan (yen)
Germany (duetch marc)

Introduce the students to the names of the countries first. If your students have prior knowledge of the countries, ask them what kinds of things they think about when they hear the names. Use the world map and the globe to show where the countries are located. Associate the countries name with their monetary value. It is not necessary to go into great detail unless you wish.

Ask the students a series of questions about money. **Example**-What do you need to get a lollipop from the store? What do you have to have to get a car? Why? Where did your parents get your bicycle? How did they get it? There may be a variety of answers which should all lead back to money.

Next, separate the students into three groups. One group will be the "Money Factory". The second group will be the "Construction Workers". The third group will be the "Grocery Store".

Each of the groups are responsible for a project. The first group has the responsibility of making money. They are to use four different colors of clay to create coins with the value of one cent, five cents, ten cents, and a quarter (red clay coins can be pennies, blue can be nickels, etc.). Next, instruct the students to make five groups of twenty so that there are at least 100 coins for each value. Finally, they need to place a sample on a board where the rest of the class can see them.

The second group is responsible for building the grocery store and the money factory. They should use the legos, blocks, and/or attri-cubes for their project. Have the students count the number of pieces (if this is a kindergarten group, they may need assistance). Now the students should give four of the colors that they use, values of a penny, a nickel, a dime, and a quarter. Finally, they should tabulate the total cost of each project and write it down.

The third group is responsible for setting up the grocery store. Using the crayons, butcher block paper, play food, and construction paper, they can begin to set up a store. They can make a list of forty food items, draw pictures of twenty items, make "for sale" signs, and give each item a price which is not more in value than twenty-five cents.

Now, you are ready to move to the second stage of the lesson. The money factory group should set aside twenty coins and divide the rest among themselves. They should take the money that they set aside and go and pay for/on their factory at the construction workers site. Next, they should go to the grocery store and buy some food.

The grocery store group should have one or two cashiers and someone to bag the groceries (this is a fantasy/pretend store so do not worry about them having enough play food for everyone). While the store is in action, one of the group members can go to the construction workers and pay for/on the store.

Finally, the construction workers can close shop and go to the grocery store with their money.

Conclusions:

Basically, there are many ways to expand the lesson. Discuss what was taking place. This is a whole language lesson that incorporates many things. The community workers, grocery store, the treasury, foreign countries, foreign currency, etc. It is possible to take this to higher levels if you wish and it shows that "money matters".

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Budgeting Money

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Objectives:

Students will be able to understand how to budget a monthly income.

Students will develop basic math techniques integrated with reading and social studies skills.

Students will be able to search employment within the want ad section of a newspaper.

Students will be able to understand the difference between a necessity and a want.

* This lesson is designed for grade levels 6-8

Materials Needed:

Budget Sheets

Newspaper (renting and job section)

Play Money

Short Story (optional)

Toy Cars (prices listed)

Toy Houses

Strategy:

This lesson is designed for each child or group. Have students decide on a occupation from a newspaper want ad. Ask questions concerning needs and wants in their lives with the cost. Make a list on the board of a monthly expense. Divide yearly salary into 12 months. Children will receive a month's salary in play money and spend it while budgeting and planning.

* Start lesson with a word problem.

Nancy wants to go to summer camp for 3 weeks. Each week costs $76.00. She has saved $232.00. Does she have enough money to go for 3 weeks?

* Allow each group or child to demonstrate their answer.
  Children can use play money, blackboard or paper.

Performance Assessment:

Teacher observation and completion of the budget worksheet. Students must be able to budget a monthly salary.

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Converting Celsius To Fahrenheit

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Objectives:

1. As a result of the lesson students will be able to solve multiple step equations involving addition, multiplication, and division.
2. As a result of the lesson students will be able to convert a known temperature in celsius to an equal temperature in fahrenheit.
3. As a result of the lesson students will be able to accurately read a thermometer in degrees celsius.

Materials Needed:

1. 6 thermometers in degrees celsius
2. 1 cup of hot water
3. 1 cup of regular water
4. 1 thermometer in degrees fahrenheit
5. calculators for each student

Strategy:

I opened my lesson with a short story. The story talks about me driving to my doctors office on a hot summer day trying to figure out if the temperature had reached 100 degrees fahrenheit. As I drove around all I could see were temperature readings on banks in degrees celsius. Eventually I arrived at my doctor's office. As we talked about the weather we both began to wonder what the temperature was outside. I told him that the bank signs all showed 39 degrees celsius. However, a temperature in celsius does not really tell us if it is 100 degrees fahrenheit. Thus we have created a problem that we need to solve. Is 39 degrees celsius about 100 degrees fahrenheit?

Now you can present the formula developed by Anders Celsius in 1742. The formula says that if you know a temperature in degrees celsius you can convert it into degrees fahrenheit by: $F=9/5(C)+32$. To check and see if this formula works, we will convert the known temperatures at which water freezes, 0 degrees celsius, and at which water boils, 100 degrees celsius. They should convert to 32 and 212 degrees fahrenheit respectively. Students will then convert 10 celsius temperatures to fahrenheit in their cooperative learning groups. Remember to follow your order of operations when solving these problems. Have students go to the board and explain their answers.

Introduce students to the 6 different stations. Each station has a thermometer in degrees celsius. Station 1 is outside, station 2 is in the back of the room, station 3 in the front of the room, station 4 in the hallway, station 5 in a cup of hot water, and station 6 is in a cup of regular water. Ask students to predict which station is the hottest. Then list them from hottest to coldest.

Now allow students to travel to each station and record the temperatures at the stations in degrees celsius. While waiting to go to the next station, students will convert temperatures to degrees fahrenheit. After all groups have been to each station confirm whether or not everyone has the same answer. Then see how many people made the right prediction. After checking predictions and answers use your fahrenheit thermometer to check the temperature of the hot and regular water. You should come out with fairly accurate numbers.

To close this lesson you can take a briefcase with a three digit combination and place it in front of the class. Tell them that you forgot the combination, but you remember that you set it on a day when it was ___ degrees celsius. If they can convert this temperature to degrees fahrenheit, they will have the combination. Let students work in their groups and come up with their answer. Give each group a try.

Performance Assessment:

1. Students will read the temperature of 6 different thermometers in degrees celsius.
2. Students will convert 6 temperatures in degrees celsius to degrees fahrenheit by using a formula.
3. Students will solve multiple step equations involving addition, multiplication, and division.

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Percents

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Objectives (Grades 3-5):

Rename ratios, decimals, and fractions as percents.

Change ratios into percents.

Weigh items on a scale.

Multiply decimals.

Use math skills to solve problems.

Materials Needed:

cardboard paper, cut-out multi-colored bars, base-ten grids,

scale, scissors, glue, pennies, beads (necklaces)

Strategies:

Tell students that percents, fractions, and decimals are also numbers. They are different ways of writing how much of something. They are names for the same quantity.

Have students record all answers on a large chart in fractions and/or decimals.

Define the meaning of the word **cent** and **per cent**. Then introduce words that contain the prefix **cent** in them such as **century, centimeter, centipede, centennial, centigrade**. Ask students to write these words at least three times.

Ask each group to place a number of pennies on a base ten grid (not exceeding 30) and ask them to read that in the form of a ratio, then write that as a percent, a fraction, and a decimal.

Distribute bead necklaces of different colors and ask students to count the beads and write their answers next to the corresponding colors. Then ask them to add all the beads up and write the total (and all answers) on the chart under the correct column.

Next ask the students to find the percent of beads in each necklace from the total. Remind them that the percents should total a hundred.

Now send one student from each group to weigh the necklace on the scale and have them record the weight on the chart. Add total weight of the beads and then find the percent of each.

Tell the students that it costs a manufacturer a certain amount of money to produce one bead. Write these amounts on the chart. Then ask to find total manufacturer's cost.

Write store prices per necklace on the chart. Let them find the profit the store makes and find the profit as a percent of the cost.

Have students look at the store price column and calculate the amount of sales tax.

Add the amount of sales tax to the store price. That would be the cost to the consumer.

Have students find examples of percents from newspapers and magazine ads, cut them, and paste them on a piece of construction paper. Have them display their work.

Performance Assessment:

Ask students to come up with seven or eight titles of Disney Classics. Have them vote on their favorite movie and then find the percent of student votes each title received. Construct a chart using multi-colored bar graphs to show those percents.

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Uncorking Work Problems

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Objectives:

To solve problems about work, using the formula work = rate x time.
To solve equations containing rational expressions.
To strengthen basic skills learned in Algebra.

Materials Needed:

A large clear plastic bottle with 3 different sized holes drilled in the bottom
3 corks to fill the holes
A plastic storage crate
A plastic container that fits into the storage crate
A plastic funnel
Stopwatches
A pliers
Rags to wipe up spills
Saran wrap
food coloring
colored strips of paper

Strategy:

The students perform the following demonstration for their classmates under the direction of the classroom teacher. No prior knowledge of the activity is needed by the students.

Have the students fill the bottle with water and place it on the crate. Place the container in the crate to catch the water when the bottle is drained. Place one colored strip of paper near the top of the bottle, but below the water level. The other strip should be placed on the bottle near, but not exactly at, the bottom. Add food coloring to the water to make the event easier to see. Place a piece of Saran wrap on the top of the bottle to form a seal. Using the pliers, remove the smallest cork. Remove the Saran wrap and start the stopwatches when the water level reaches the top of the first colored strip. Stop the stopwatches when the water level reaches the top of the second colored strip. Recork and refill the bottle. Record the time it takes to empty the bottle using the smallest hole. (I got 127 seconds.)

Again drain the bottle as before but pull the middle sized cork and record the results. (I got 65 seconds.)

Now ask the question, "How long does it take to drain the bottle if both the smallest and middle sized corks are pulled?"

The formula, Work = Rate x Time is introduced and our discussion leads to the following chart, equation and prediction for the time.

	Rate	x	Time	=	Work
Smallest Hole	1/127		127		1
Middle Size	1/65		65		1
Both Together	1/t		t		1

$$\frac{1}{127} + \frac{1}{65} = \frac{1}{t}$$
$$65t + 127t = 65(127)$$
$$270t = 65(127)$$
$$t = 43 \text{ sec.}$$

Again drain the bottle by pulling both the small and middle sized corks and record the result. (I got 43 seconds---Perfection!)

A variation of the above can be obtained by first draining the bottle by uncorking the middle and largest holes and predicting the time needed to drain the bottle using just the largest hole. Here some error might appear in the timing of the event.

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Mass and Weight in the Metric System

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Objectives:

To choose the most reasonable metric unit of mass.
To work in a group to weigh objects in the metric system.
To solve problems using milligrams, grams, and kilograms.

Materials:

Simple balance scale
Set of gram weights
Everyday objects to be weighed in grams, milligrams, and kilograms

Strategy:

For each group have students weigh and record the mass of various objects.
Compare the weights of objects by holding gram weights in one hand and the object in the other hand.
Work in a group and decide which measure should be used for each object.
Estimate weights before measuring on scales.
Calculate students weight in kilograms.
Use mini-scale to measure in milligrams.

Performance Assessment:

Students will be able to estimate whether to measure objects in milligrams, grams, or kilograms.
Students will be able to use balance scale to determine weights of objects for lesson in g, mg, and kg.
Students will be able to identify metric-unit relationships.
Comparison of student results with teacher results will be the final assessment of the lesson.

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Uniform-Motion Problems: Just Playing With Cars

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Objectives:

To solve uniform motion word problems using rate X time = distance.
To practice measuring in the metric and English systems.

Materials Needed:

At least two battery operated cars with constant velocity,
Measuring tape with both English and metric systems at least 50 feet or 15 meters, meter and yard sticks,
Stop Watches at least two or more if possible,
masking tape

Strategy:

The students perform the following demonstration for their classmates under the direction of the classroom teacher. No prior knowledge of the activity is needed by the students.

First, with masking tape mark the starting and finishing lines for calculating velocity over a fixed distance. (I used 800 cm.) Find the time needed for each car to transverse the fixed distance. Record the time and distance on the blackboard and then calculate the velocity of each car.
(25 cm/sec and 36 cm/sec)

Now introduce the first type of Uniform-Motion Problem, "If the cars are place back to back and travel at the same time in opposite directions, when will they be 1000 cm apart?". Explain the problem first as the cars are placed on the floor back to back and run off in opposite directions. Next use the standard associated pictures and charts for this type of problem, write the equation and solve it in the usual manner.

$$25t + 36t = 1000$$
$$61t = 1000$$
$$t = 16.39$$

Place the cars back to back on the floor and let them run for 16.4 secs. and measure the distance between the two cars. (It should work. I got 1020 cm.)

Now introduce the second type of Uniform-Motion Problem, "If the two cars are 750 cms apart and they each travel towards each other at the same time, when and where will the two cars meet?". Set the cars on opposite sides of the room and let them run into each other as you begin your explanation. Again use the standard associated pictures and charts for this type of problem, write the

equation and solve it in the usual manner.

$$25t + 36t = 750 \qquad (12.29)(25) = 307.25 \text{ cm}$$
$$61t = 750$$
$$t = 12.29$$

They should collide in approximately 12 secs, 307 cm from where the slower car starts. Mark that spot on the floor. Place the cars 750 cms apart and run them at each other. (I missed by 6 cm.)

Performance Assessment:

With two faster cars mark the starting and finishing lines for calculating the velocity over a fixed distance. (I used 20 yards.) Also mark two starting lines on opposite ends of the hallway. (65 yards) In teams of 3 or 4, the students find the velocities, make the associated picture and chart, write the equation and solve it in the usual manner, and mark the spot in the hall where the two cars will collide. (This is competition at its best.)

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Estimating and Counting Money

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Objectives:

The purpose of this lesson is to review estimating and rounding to the nearest dollar as well as gain skills and practice in counting money. The students will define the meaning of estimate and rounding. The students will gain experience in estimating sums and products.

Materials Needed:

Toy cash register, game sheets, identification cards, play money, and Jewel Food Store adds.

Strategy:

The students will play "Estimate the Cost" - a game similar to tic-tac-toe. At the top of this game sheet are pictures of six different items with the price tags attached. There are two game boards on the page (Game 1 & 2). Each board contains nine boxes with various dollar amounts in each. The students will select two items. Next they will round the prices to estimate the cost. The cost will be located on the game board and marked with an X or an O. Three marks in a line wins. Next the students will play "Estimate It". This game follows the same rules, however, there will be four items in each line as opposed to three items in each line in the first game played. The final game will be "Estimate a Meal". In this game, the students will be divided into groups of four. One student will be given a "breakfast" card to wear, another student will be given a "lunch" card to wear, and the third student will be given a "dinner" card to wear. Another student will wear a "cashier" card. The students with the "meal" cards will use Jewel Food Store adds to select four to six items for their particular meal. Next, the students will estimate the cost of their meal (individually), go to the "Cash Machine" and make a withdrawal using play money. Following this, the students will then go to the Jewel Food Store and make their purchases. They will be given a total by the "cashier". At this time the students will pay the cashier using the play money. The cashier will then give the students their change by counting aloud. The students will then count the change they received.

The counting of the change is the concluding activity.

Performance Assessment:

The teacher will evaluate the students as they estimate, count money and make correct change using play money.

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Estimation

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Objective(s): **Grade level: 5th through 8th**

- The students will be able to estimate numbers of objects by sampling.

- The students will be able to contrast and compare sampling with guessing.

Materials Needed:

	bag of Baby lima beans
	box of Creamettes Marcaroni
4 oz.	containers with lids plastic (Clear)
12-inch	trays
	color markers and crayola chalk
12-inch	rulers
36-inch	poster
1	overhead Projector
	pre-labeled broken-line graphing paper with transparencies

Strategy:

Have the students:

. divide class into groups of four
. guess a full container of Baby Lima Beans & Macaroni
. select dual roles: estimator, recorder, checker, and reporter/Grapher
. record the number of guesses on data sheet and broken-line graph
. use one scoop, marker, ruler, 4 oz full container with lid, and tray
. take one scoop for estimate from 4 oz container of Baby Lima Beans & Marcaroni
. estimate count for full container
. check the number Baby Lima Beans & Marcaroni count
. report the result of guesses and sampling to the class
. use the transparency sheet for broken-line graph on the overhead projector
. discuss the high and low points of guesses, sample, and estimate count on the graph to the class

Conclusions:

Students will learn to:

- estimate by taking a sample
- make a broken-line graph to analyze data
- improve cooperative learning skills by role playing

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Using A Round-O-Meter To Estimate

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Objectives:

The student will demonstrate knowledge of rounding numbers to the nearest dollar or nearest dime.

Materials needed:

scissors	string	tape	pencil
Round-O-Meter	worksheet	Round It Game	overhead
Overhead School Store		paper base ten blocks	
graph for base ten blocks			

Strategy:

1. Introduce several items that students would need to purchase for school. Write the items and their cost on the board. Talk about how we need to round to get an idea of how much money we need.
2. Using paper copies of the base ten blocks on a graph show if a number falls above or below the half mark. If we are closer to the first number we round down, if we are closer to the second number we round up. For our lesson we will let 1 flat represent a dollar, one rod represent a dime and one unit represent a penny. Demonstrate several of the items that the students mentioned. Pass out individual pieces of the base ten papers and a graph so the students can try this for themselves.
3. A Round-O-Meter is an instrument that we will make to show us which direction to round. The Round-O-Meter is a piece of paper about the size of a ruler. Attach a piece of string to the center of the Round-O-Meter, one end is folded into an arrow. Write the numbers 1, 2, 3, 4, 0 on the end of the strip with the arrow. Write the numbers 5, 6, 7, 8, 9, on the other end of the paper. When you hold the Round-O-Meter by the string and put a paper clip on the number you are looking at, the arrow will go up or down. This will show the children which direction to round.
4. After the children use their Round-O-Meter several times to prove to themselves that it will work there is a follow up worksheet that they can use to reinforce their new skill.

Conclusions:

Showing the children that one number is closer to another is very beneficial in that they can easily figure which direction to round. The Round-O-Meter serves as a reminder and is something that they can keep at their desk.

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Flight Angles Of Inclination

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Objectives:

The students will:

1. Observe the flight of a glider.
2. Measure the distance flown from a given point.
3. Analyze the effect of a change of angle of inclination on the launch/flight of sling launched gliders.
4. Collect data on distance flown when glider is launched from two different angle-ramps.
5. Record and communicate test results to the class by use of a horizontal bar chart for students to generalize conclusions from data. The effect of angles and comparison of their size/measure will be given by students.

Materials needed:

Glider
Trundle wheel
Yard stick
Ramp
Airplane Flight Chart
Hinged Angle

Strategy:

1. Explain that airplanes have engines and gliders do not.
2. Use a chart to demonstrate angles of flight for airplanes.
3. Demonstrate how to launch glider from ramp, use trundle wheel and record data.
4. Divide the class into four groups. Distribute a glider, trundle wheel, yardstick, an angled ramp, and data collection sheet to each group.
5. Proceed to a launch site (outside, weather permitting).
6. Launch gliders, measure distance traveled, and record results.
7. Students will assume the following roles:
   Pilot-to launch glider from ramp
   Navigator-uses trundle wheel to measure distance traveled
   Air Traffic Controller- assist in location of straight line distance of flight and checks trundle wheel reading
   Flight Attendant- stabilizes ramp and records data.
8. Each student assumes each role once and ramps should be exchanged by each pair of groups.
9. Return to class, discuss and analyze data using a pictograph.

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Money Sense

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Objectives:

1. To identify and know the value of quarters, dimes, nickels, and pennies.
2. To use a variety of coins to show the value of a dollar.
3. To count the exact amount of purchase.

Materials:

ziplock bags, paper, pencils, paper coins, plastic coins, plastic store fronts, doll clothing, markers, books, folders, clay, cars, crayons, kites, coloring and activity books, glue, paint, puzzles, cars, candy, cookies, canned goods, cereal, scissors, sidewalk chalk, posterboard, store signs, and any items of interest to your class

Strategy:

1. Identify penny, nickel, dime, and quarter.
2. Give value of each coin.
3. Count to a dollar using:
   a. nickels; b. dimes; c. quarters; d. various combinations of denominations
4. Instruct students to come to the front of the room to observe the items which are for sale. They are to choose as many items as they can for the amount of money they have on the shopping spree work sheet without going over the amount.
5. Have a student from each money group ($ .49, $ .60, $ .75, $ .83, and $1.00) come to the chalkboard to list the items they chose and discuss the reasons for their choices.
6. Tell students to come to the class store to purchase one item and take the item back to their desk. They must be able to count the exact amount of the item.

Conclusion:

Use of these activities should familiarize students with counting various combinations of denominations of coins to a dollar.

Evaluation:

Give quiz consisting of ten problems which will demonstrate the student's ability to count various amounts of money less than or equal to a dollar.

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Percents: (An application to real life problems)

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Objective: (Grade 7)

The students will be able to find a percent of a number by multiplying by a fraction or a decimal equivalent to that percent.

Materials Needed:

One overhead projector, transparencies (4), calculators, play money, construction paper, poster boards, pencils and a variety of items to sell at the General Store.

Recommended Strategy:

Review with the students how to write a percent as a fraction and as a decimal. Use a circle graph with expenditures. Have the students guess what percent of the circle represents each of the expenditures. Discuss with the students how to calculate a bill for a restaurant meal. They should know about the local tax and tipping customs in the area. Let's call this activity 'Purchasing Power Buying Smart'. Have each student bring a menu or create one. The group will cooperate by choosing one menu they will use for the activity. Create a restaurant atmosphere on one side of the room and a general store on the other side of the room.

Procedure:

Divide the class into groups of five and give each student a menu. Each member of the group will have an opportunity to order whatever they desire from the menu. Assign one student to play the role of waitperson to write down the orders for the group. Have each student calculate the bill for his or her fantasy meal (use a calculator for the food and the tax total). Another student may figure out the tip. The waitperson will then collect all bills in the group and make a final tally to present to the cashier. After the fantasy meal, students have a job to do at the General Store. They will compute the discount prices on selected items to be sold on the following day.

Performance Assessment:

Choose a group of three students. The first student will write a percent of a number. The second student will solve it by using a proportion. The third student will solve it by using an equation. Students take turns in all three roles.

Multicultural Connections:

Student should know that the ancient Egyptians invented proportional scale drawing. In Egypt and Babylonia taxation was based on proportion. A given measure of wheat was the required tax for every one hundred cattle.

Conclusion:

This activity was fun as well as cooperative learning. Students used hands-on methods to calculate sale tax, find discounts and sale prices using percent. Students will use this knowledge to solve problems of applying percent in everyday situations.

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Real Numbers in the Real World

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Objectives:

Students will be able to group the set, R, of real numbers into two different sets: $R > 0$, $R < 0$.

Students will be able to use parentheses to change the order in which exponentiation, multiplication, division, addition and subtraction are performed by using the TI-34 calculator.

Students will be able to work problems throughout the set of real numbers using the TI-34 calculator without preference for positive numbers.

Materials Needed:

Set of TI-34 Calculators--one for each student.

Strategy:

Inform the students that the real number system consists of natural numbers, whole numbers, integers, rational numbers, and irrational numbers. Students must be able to comfortably use the whole set of real numbers to perform the mathematics operations in order to be successful at working problems in the real world. Give example problems that include numbers in the subsets of the real number system initially. Have students work these problems on the calculator. Finally, include problems that involve all the real numbers and all the operations. Have students work these problems on the calculator. Emphasize to students that the calculator is only a tool for them to use. The students must know the operations of mathematics for the calculator to correctly perform the arithmetic. This allows the students more time to learn and become comfortable in applying principles of mathematics to problems and opportunities they encounter in the real world.

Performance Assessment:

a. Give students a set of 20 problems that include parentheses, exponents, multiplication, division, addition and subtraction.
b. Have students work the set of problems without the use of calculators.
c. Have students use the calculator to work the same set of problems.
d. Compare the scores on the two sets of problems.
e. Have students discuss advantages and disadvantages of using calculators in class.

Multicultural Application:

Calculators and real numbers can be used efficiently by all cultures. Wise use of the calculator as a tool can expedite mastery of new subjects and material in mathematics.

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Manipulating Formulae...Using Recipes To Understand

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Objectives:

1. The student will write recipe amount changes to any given increase or decrease.
2. The student will be able to fill in missing data for any given situation.
3. The student will understand the importance of formula applications to everyday life.
4. The student will develop a tentative understanding of writing and using formulae.

Materials Needed:

Recipes (multicultural, family, commercial), Formula worksheets, Sugar, Unsweetened lemonade.
The class will be divided into groups of four, with the desks of the students in each group facing each other.

Strategy:

This mini-teach is directed toward any grade level in order to introduce and give a foundation to the importance of formulae and their accuracy. To understand the step by step method of transferring and transposing amounts and variables on paper, students will use their recipe addition and multiplication skills by first attempting to make something (lemonade) without a formula -and tasting it- then using a recipe for the lemonade -and tasting it again. From this stage, paper and pencil work will occur with baking or cooking recipes, scientific formulae and finally word problems.

Students will rearrange their desks to form groups. Four problem situations and a performance assessment will be given to each member of each group, one situation at a time. Group discussion of each situation will be approximately five minutes. Only after the first situation will the class come back together to discuss their set of directions. One student from each group will read their directions as another follows along on the chalk board (or transparency on the overhead) evaluating and checking that the adjusted amounts work. If other groups have the same amounts of substitution we will move on. Otherwise we will discuss the variety of ways of increasing or decreasing formula amounts. The students will regroup and discuss the remaining situations which will be given to them in five minute intervals. Again, as a class we will discuss their outcomes.

The next activity will allow the students the creativity of making a formula "fit" any event or incident. After five minutes a class discussion will be held.

A final phenomenological application word problem will be given. The students will read and work the problem together.

Lastly, a rubric will be given evaluating the activity which required working a formula (any type which "fits" the activity or incident).

Performance Assessment:

Scoring Rubric

DEMONSTRATED COMPETENCE 5 POINTS
- -includes clear and concise mathematics
- -demonstrates an understanding of the concept
- -applies the formula
- -presents a clear connection to the formula and the situation by explaining the variables and what they represent
- -evaluates why the answer makes sense

SAME AS FOR 5 POINTS OMITS **ANY** ONE OF THE ABOVE POINTS 4 POINTS

SATISFACTORY RESPONSE 3 POINTS
- -includes "some" mathematical approach, no matter how embryonic
- -presents a connection to the attempted formula and the situation by "making sense"
- -evaluates or discusses what kind of answer should result

INADEQUATE RESPONSE 2 POINTS
- -discussion is not understandable from the writing
- -discussion is inaccurate
- -lacks any connection of variables and situation

NO ATTEMPT WHATSOEVER 1 POINT

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Problem Solving Using Percentages

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Objectives:

The student will be able to recognize the three basic types of Percentage Problems.

The student will be able to:

1. Find what percent one number is of another.
2. Find a percentage of a number.
3. Find a number when the percent is known.

Materials Needed:

1-16 oz bag of plain M&M's; 19-4oz bags of M&M's; 19 plastic bags;
1 black marker and 19 pencils; 19 student folders with plain writing paper;
l9 M&M Math handouts and 19 calculators: Overhead projector.

Strategy:

All of the students are given a folder with a small plastic bag and one small bag of plain M&M's. The students are asked to guess how many M&M's are in the bag. They are asked to put their M&M's into sets by color and write the number of M&M's they have in each set. They are also asked to use > or < or =, to show the relationship between these sets. Students put l5 M&M's in front of them. Then they are asked various questions, for example, how many piles of fours can you make? What is left?

The teacher demonstrates three types of word problems on the board to find percents by using ratio and proportion. The overhead projector is used to illustrate the same problems, but in a different way. For example:

a. The student is given the following information;

1. the number of red M&M's in the small bag.
2. the total number of M&M's in the small bag.
3. the total number of M&M's in the big bag.

The student is asked to find the number of red M&M's in the big bag.

b. A bicycle is on sale with a coupon for 25% off which is a $l5.00 savings. How much is the bicycle without the coupon?

c. A set of stereo speakers is priced at $125.00. The sales tax is 8%. What will be the total price of the speakers?

d. In a photo, Carlos measures 8 centimeters. He is actually 56 inches tall. In the photo his brother, Juan, measures 7 centimeters. How tall is Juan?

Performance Assessment:

The students will be given a post-test. The students will be able to tell how many M&M's are in the big bag as compared to their small bag of M&M's. Students already know that there are 88 red M&M's in the big bag and that there are a total of 527 M&M's in the big bag.

Multicultural Aspects:

Percent comes from the Latin phrase per centum, which may be translated by the hundred, to the hundred, for each hundred. The symbol for percent is %. Thus, 85% means the ratio 85 to 100 or 85/100. Percent is used for mathematical calculations throughout the world in everyday living regardless of nationality.

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Whole Language Approach in Solving Word Problems

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Objectives:

To formulate addition and subtraction problems of whole numbers. To relate everyday language to mathematics meaningfully. To use problem-solving approaches to investigate and understand mathematical content. To identify point of view in a selection.

Materials needed:

1. **The Real Story of the Three Little Pigs** by Jon Scieszka
2. **The Three Little Pigs** by Paul Galdone
3. Math vocabulary cards for words such as the following:
   altogether   in all   many more
   each   left   total
4. Reading vocabulary cards for the following words:
   Al   blow   brick   cake   granny   house   jail
   Magic   Michael   newspaper   Sean   stick   straw
5. Crayons
6. Pencils
7. Plus and minus cards for every child
8. Head bands for three pigs (pink) and one wolf (brown)
9. Ditto to make equations
10. Objects to represent story problems (books, balls, pencils)

Strategy:

This presentation is appropriate for use with primary children. The teacher will review the story of the **The Three Little Pigs**. After discussion, the teacher will call four students to represent the characters of the story. The teacher will have students answers questions from a card listing age, favorite toy and food and how much money each character has. Using the characters the teacher will review the story and make up story problems and answer them.

Read **The True Story of the 3 Little Pigs.** Ask appropriate questions about the story. Give the pretest. Give story problems orally having the students put the correct answer only on the test. After the pretest, the teacher will go over the story problems using role playing with the students. Explain to the students that we must find a better way to solve story problems.

Introduce the math vocabulary words. Tell them that each word has a correct operation. Example: "in all" means to add (+) or "many more" means to subtract (-). Pass out the + and - cards. As you say a story problem, have students hold up the correct card. You may also have students make up story problems orally. Another student will give the answer.

Performance Assessment:

Tell the students that you forgot to tell them that they must decide who is telling the truth, the pig or the wolf. They must write some sentences telling who they believe and why. Also draw a picture.

Finally the students will write story problems using the above math vocabulary words.

Multicultural:

Students should know that many people contributed to the development of modern arithmetic and the origins of arithmetic are international.

Conclusion:

The student will be able to identify key words in solving addition and subtraction word problems.
The student will be able to identify point of view in a selection.

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Effective Use of Living Space

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Objectives:

Students will be able to measure the area of a room.
Students will be able to measure various objects in this room.
Students will be able to place scale model furniture in a room and determine the area occupied.
Students will be able to calculate the percentage of space used.

Materials needed:

Students will need a yardstick, scissors, glue, scrap paper, quad paper and pencil.

Strategy:

Students will use the yardstick and measure the length and width of the room, table, teacher's desk and cabinets.

Instructor will pass out sheets of paper containing shapes resembling living room furniture that has been drawn to scale. The students will place certain pieces on the quad paper and measure the area occupied by the furniture.

Students will determine the amount of the space used and compare it to the total amount of space available and calculate percentage.

Conclusions:

Students will find that they are able to place furniture in a room with the use of scale model drawings.

Students' understanding of length, width and area will be reinforced.

Students will find that the actual amount of space they can effectively use will be less than fifty per cent.

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Making Predictions

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Objectives:

This outside activity will help students at any level learn to classify and make predictions and will teach students about ecology and plant life at the same time.

Materials Needed:

Clothesline wire (cut to 88 3/4 inches in lengths)
Paper and pencil
Masking tape
Twine

Strategy:

Discuss with students that their school grounds and neighborhood parks can be the perfect setting for a math lesson. Let's call this activity "Hoop It Up".

MAKE THE HOOP:
1) Cut five pieces of wire 88 3/4 inches long. (Add an extra inch for overlap.)
2) Bend the wires to make hoops.
3) Tape the wire together.
4) Cut ten pieces of twine.
5) String two lengths of twine across each circle to make four quadrants. (A hoop this size will represent about 1/10,000th of an acre. There are 43,560 square feet in an acre and 1/10,000th of this is 4.356 square feet, which is the area within the hoop.)

Directions:

Divide the class into groups of five and give each group a hoop.
Take the class outside on the school grounds or to a park and have the students toss their hoop onto the ground.
One student should stand beside each quadrant and the fifth should stand near the hoop with paper and pencil to record the information.
Have each student count the number of things he/she finds within their quadrant.
The students will count plants, insects, rocks and other non-living things.
Students will relate each item that they count to the group secretary.
Upon returning to the classroom ask students to classify their objects in three groups: plant, insect or mineral.
Question: Which group found the most objects in each category?
Students will predict how many of one item, plants for instance, would be found in a whole acre.
To do this each group should total the number of plants in its four quadrants.
The hoop represents 1/10,000th of an acre. The groups must, therefore, multiply their totals by 10,000 (Primary children will need assistance in doing the math operations).
Compare the groups' totals. Question: Are the totals similar?

If not, discuss why the groups got different results.
Were some parts of the ground more lush than others?
A more accurate prediction can be made by following these steps:

1) Add the total number of plants found in all groups.
2) Divide by the number of groups and multiply the quotient by 10,000.

Have the students perform this operation and make similar predictions with other objects on the list.

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Estimation Contest

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Objective:

Students will gain a more concrete understanding of the subtle difference between a guess and an estimate.

Materials Needed:

Large box of Cheerios or other similar cereal
32 oz. or 48 oz. container (translucent or transparent)
Cups for each student or group of students (an odd size cup will offer the greatest challenge, i.e. 6.8 oz. or 7 oz.)
Paper plates
Paper and pencil

Strategy:

Estimation is a powerful mathematical idea to be used both in solving problems and in checking the reasonableness of results. When the student wants to know about how long it will take to earn enough babysitting money to buy a new bicycle he or she can estimate the answer. Estimation should be used to solve problems for which exact answers are inappropriate and to check computation results.

We all make estimates everyday. How long will it take you to walk to school, how much food should I put on my plate for dinner, how many times will Mother call me before she comes to look for me, etc.?

The Estimation Contest is a fun and easy way to allow the students to make "educated guesses".

1) Fill the large container (32 or 48 oz.) with the Cheerios or similar cereal. Try to use only whole pieces, not broken ones. Count the number of pieces.

2) Write the number of pieces and put this information in a safe place. (Do not put this information on the container).

3) Give each child, or group, a paper plate, a cup, paper and pencil. Tell the students the capacity of the cup (7 oz., 8 oz., etc.). Tell the capacity of the large container.

4) Give each child more than enough cereal bits to fill their cup.

5) Ask students to estimate the number of cereal bits in the large container. They may use whatever measuring devices they think will help them get the best estimate.

Example: You have a 48 oz. container filled with Cheerios and the students are given a 6 oz. cup:

$$\frac{\textbf{VOLUME OF CONTAINER}}{\text{VOLUME OF CUP}} = \text{number of 6oz. cups required to fill the large container}$$

Therefore: $$\frac{\textbf{48 oz.}}{\text{6 oz.}} = \text{\# of 6oz. cups required to fill large container}$$

The number would be 8

8 cups X 223 cereal bits in a cup = 1,784 cereal bits in the 48 oz. container

Questions:

1. How could you make your estimate more accurate?

2. Given a weighing apparatus, could you estimate the weight of the cereal bits in the large container?

Extension:

Show children the difference between a guess and an estimate. Set up several guessing stations in your classroom. One might be guessing the length of a piece of rope, another might be guessing the amount of popcorn kernels in a container, another might be guessing the amount of liquid in a container, etc. Point out to the students that when they guess they really aren't basing the guess on any factual information. Explain that an estimate is based on some amount of knowledge or facts that can be obtained.

Acknowledgements:

M. Matyas and J. Combs, "Proyecto Futuro". American Association for the Advancement of Science (AAAS).

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Finding Area and Perimeter in a Miniature House Using Standardized Units

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Objectives:

Finding area and perimeter in a miniature house using standardized units of measurements.
Students are able to conserve and understand that the length of an object remains the same regardless of the changes that occur in its position.
Students experience hands on measurement in finding perimeters, width and length.

Materials needed:

Glue
Staple gun
Corrugated small size furniture
One box for each house
One chair for each house
Thread
Utility knife for teacher only
Measuring tape
Felt for covering furniture
Sample carpet pieces
Masking tape
Medium heavy white tag board for tile
One television for each house
Cotton for stuffing felt pillows
Index cards
Pencils
Scissors
Rulers
Stars

Strategy:

Children are separated into groups of four students. Each group is given a medium size box. Two students are to measure the walls and two are to measure the floor area. These measurements are double checked by other team members for accuracy. The measurements are given to the "General Merchant" storekeeper.

If these measurements don't agree with the storekeeper's measurements, then the students need to rethink the formula for finding area and perimeter. No goods such as carpet, wallcovering, glue, brushes or masking tape will be exchanged for incorrect measurements. Students who measure accurately the first time receive a star on the far end of an index card or next to their measurements. (Please allow a small margin for error.)

As an added bonus, students will receive free furnishings.

Furnishings: Corrugated television sets, couches, felt pillows, chairs, tables and felt area rugs.

Conclusions:

This activity is a cooperative effort as well as cooperative learning. Students will marvel at the successful outcomes of finding area and perimeters upon completion of their miniature house. We can also assume that students will internalize the formula of width times length for area and addition for perimeter by doing this hands on activity.

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Ratios and Proportions

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Objectives:

The seventh grade student will:

Review ratios and proportions.

Determine the relationship between individual height and reach.

Find equal ratios.

Solve word problems using ratios by trial and error.

Practice finding pictorial expressions of fractions to decode a message.

Materials:

Measuring tapes or string
Chart paper
Construction paper (red, to make 15 Red beans; white, to make 15 Black-eyed peas; and green, to make 15 Lima beans)
Worksheet with pictorial expressions of fractions

Recommended Strategies:

. Form small groups of three or four students.
. Distribute measuring tape or string to each group.
. Use the tape or string to measure and compare height to reach.
. Record results on chart paper in this order:

Tall-Rectangle	Perfect-Square	Short-Rectangle

If the height > reach, record name under "tall-rectangle"
If the height < reach, record name under "short-rectangle"
If the height = reach, record name under "perfect-square"

. Students whose names are in the "Perfect-Square" column will be the Chef Cook to make the "Three Bean Salads" for the first activity.
. Distribute beans randomly (one per student).
. Write salad recipe on the chalkboard.
. Call a Chef Cook to read and make the first salad by selecting beans (students) from any group.

Each salad contains Red beans, Lima beans and Black-eyed peas

#1 This salad contains:
4 Red beans
1/2 as many Black-eyed peas as Red beans
10 beans in all

#2 This salad contains:
2 Lima beans
Twice as many Red beans as Lima beans
10 beans in all

#3 This salad contains:
An equal number of Red beans and Black-eyed peas
5 more Lima beans than Red beans
No more than 20 beans

. Groups should be encouraged to make up 3 different salads and continue the activity.

. Next, distribute worksheet to each student with fraction message:

Students will solve problems, analyze which of the coded solutions would best fit and, by substitution of the lettered answer, be able to decode the message.

. Discuss the message.

References:

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National Council of Teachers of Mathematics, **Fraction Message**. Arithmetic Teacher 36 (December 1988): 32.

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Draining the Swimming Pool

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Objectives:

For 9th and 10th grade

1. To determine the time needed to drain a quantity of water using tubes of different inside diameters (I.D.)

2. To determine the time needed to drain a quantity of water using two tubes at the same time, contrast this with the theoretical values and give explanations for the differences.

Materials needed:

Stopwatch, 3 one gallon jugs, two plastic tubes about 3 feet long of different inside diameter, plastic tray, water pails, hand calculators.

Strategy:

On a table place 3 one gallon jugs filled with water. Ask the class to estimate how long it will take to drain one jug using a plastic tube of 1/4" I.D. Show them this tube. Then, using the siphon method, drain one of the jugs using the tube. This will be timed by someone in the class using the stopwatch. Next, find the time according to the formula - $V = (2gh)^{1/2}At$. Ask someone in the Physics department about using this formula. Find "t" using the formula. Discuss differences from the experimental value. Go through the same process using the 1/2" tube. Again find the experimental value and the theoretical value and discuss the differences. Finally, using the third jug of water and both tubes, find out how long it takes to drain the jug of water. Then compare this time with the value given by the algebraic formula for the problem.

Conclusions:

Discuss differences between theory and experiment. How could the two values be brought closer together in this experiment? Discuss the role of friction.

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Sales Tax and Discounts

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Objectives:

The sixth through eighth grade students will be able to:
1. Discover that sales tax is an additional charge on products purchased.
2. Compute sales tax on different items using register tapes.
3. Discover that discount means to take a certain amount off the price of something.
4. Discuss that even if you take the discount off the purchase price of an item, you still have to pay sales tax.

Materials needed:

All materials listed are for an entire class.
1. Calculators
2. Various register receipts from different stores
3. Play money
4. Dice
5. Sales tax table
6. Practice worksheets on sales tax and discounts
7. Sample newspaper and catalog ads
8. Discount signs made up or signs discarded from retail stores

Recommended Strategy:

1. Have students collect sales receipts from different retail and grocery stores ahead of time for this lesson.
2. Four students can pretend to gamble with dice and money to introduce the lesson.
3. Stop the game at any point you deem necessary and let the winner know that even though he or she won there will be a tax on their winnings.
4. From above activity you can elicit the definition of taxes from your students.
5. Use sample grocery store receipt duplicated on a poster board to illustrate sales tax, coupons taken off, amount tendered, change. Make sure they understand that sales tax is an additional charge on purchases made imposed by the government.
6. Discuss the fact that there are different rates of sales tax for food and nonfood items and also that the tax varies from state to state.
7. Review how to change percents to decimals in order to multiply.
8. Let students use calculators to compute totals from receipts brought in for lesson. Also, let them practice computing sales tax for each purchase.
9. Students can also practice finding sales tax by using food sections of a newspaper to shop for their family and then compute the sales tax to be charged.
10. The day following this lesson you can introduce discount,define it and the fact that it varies from the regular price.

11. Use catalogs, newspaper ads and any other materials that you find to illustrate discounts.
12. After you go over with students the examples above you can give them worksheets to provide practice with discounts.
13. Students can bring in different items to mark a price on and to practice taking a percent off.
14. As a follow up to these lessons you can take the students to stores and let them actually shop, compute the sales tax and also find the discount.

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Mixture Problems

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Objective:

Ninth grade students will be able to write the equation and solve mixture problems.

Equipment and Materials:

1. Overhead Projector
2. 100 red and 100 yellow beads for each group of 4 students
3. 1 container for each group
4. 1 calculator for each group
5. 5 small cups for each group

Recommended Strategies:

1. Students will count out 4 cups of beads that are 40% red (a cup contains 15 beads) and place the beads in a container.
2. Students will count out 2 cups of beads that are 80% red and add this mixture to the container until the beads in the container are 50% red.
3. Students will complete the following table.

Original Mixture (Percent)(Amount)	Add (Percent)(Amount)		New Mixture (percent)(Amount)
________________	________________	=	________________

4. Students will solve the next two problems by repeating the steps above.
   a. Change 8 cups of beads that are 50% red to 60% red by adding 100% red beads.
   b. Change 4 cups that are 20% red to 15% red by adding yellow beads.
5. Student will solve additional problems by letting x = amount added.

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An Introduction to Percent

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Objectives:

Fifth grade students will develop a basic understanding that percent is a comparison of some number to 100.
Pupils will convert fractions to percent, percent to decimals and vice versa with a minimum of 90% accuracy.

Materials:

Per team: 2 sheets of $1cm^2$ graph paper; 2 pairs of scissors;
1 sheet of 100 squares. marked with 12% "A's". 16% "B's", 18% "C's",
5% "D's", 3% "E's", 8% "F's", 13% "G's" and 25% "H's".

Strategy:

Develop the idea that percent is a comparison of some number to 100 which can be written in the form of x with the sign % or x%. Think of the symbol % to be a distortion of the 100 in a ratio of x:100. The ratio of 20 to 100 is 20 percent or 20% and this is the same as 20 hundredths or 0.20. Therefore, 20 parts per hundred can be renamed as 20/100, 20% or 0.20.
Show 50/100 as .50 as 50%. Follow up with 75/100, 30/100, 10/100, etc. Have pupils rename other ratios of 100 as percent and decimal.
We know that 50/100 = 1/2, 75/100 = 3/4, 20/100 = 1/5 therefore we can show that 1/2 is 50%, 3/4 is 75% and 1/5 is 20%.
To convert fractions whose denominator is something other than 100, you must first rename the fraction with a denominator of 100.

Divide the students into teams of 3 or four. Have one student in each team cut a 10cm by 10cm square off a graph sheet. Count the number of sq. cm. in the square. There are 100 sq. cm. On chalkboard write this value as **100/100 = 100%**. Point out that 100% is **all** of the squares or 100 squares.
Cut a second 10 by 10 square. Compare it with the first. They're equal. Now cut this second sheet in half. Count the number of square cm. in each half. There are 50. On the chalkboard show this as **50/100 = 50%**. Since 50/100 is half of the 100 original squares we can say that 50/100 = 1/2 which also equals 50%.
Follow the above sequence and have the students cut out 25, 20, 10, 1 squares. Compare them to the original 100, write them as fractions of a hundred and convert the fraction to percent.

Use the graph sheet marked with letters "A" to "H". Count the number of "A's". Write as a fraction of 100 (12/100). Convert to percent (12%). Continue the same procedure with the other letters.
Have teams make up a letter sheet of their own, exchange with other teams and determine the percent of each of the letters.
Pupils should be able to convert percent to a fraction with a denominator of 100 and rename the fraction as a decimal.

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Solving Word Problems

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Objectives:

(Intermediate and upper grades.)
To Teach intermediate students several different techniques for solving Word Problems.

Materials needed:

Overhead projector, the three different strategies dittos, and Bingo manipulatives for the culminating exercise.

Strategies:

Demonstrate and explain why it is important to study word problems. Show by examples that word problems are found in all subjects including Social Studies, Science, Language Arts, and every day life. Present and demonstrate the three different strategies, as you would in the classroom. The strategies are:

Determining the procedure, finding the clue words, changing the problem to a number sentence, getting the inverse of the problem, make a good estimation and solving the problem.

Finding the characters, setting, plot, problem, and the resolve or solution.

Get an understanding of the problem, which includes who, what, how many or much, planning a solution and finding the answer.

Conclusion:

The students will not be expected to use all of the strategies or even all of one, but to determine what will work for them and use that one.

Evaluation:

To determine if the students have assimilated the concepts, they will play Word Problem Bingo. The word problems will be projected on the overhead and the answers will be on the individual game cards. The first one to get four consecutive numbers in any direction, wins.

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PROBLEM SOLVING: STEPS AND STRATEGIES

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Objectives

To learn, or reinforce problem solving skills using these steps: l) Read and re-read the problem,at least three times. 2) Restate (list) the "facts" given, and rephrase the question. What information is needed? Is there extra information included? What's missing? Would a diagram, drawing, chart, or graph help? Organize what is known and what is needed. 3) Predict, estimate the answer, within a reasonable range. How does the problem connect with concepts, facts, already acquired? 4) Select a strategy or combination of them. 5) Work the strategy to solve the problem. 6) Check the solution in terms of the question. Does it make sense? Can it be demonstrated, extended, or applied further?

Materials

Several examples of problems on handout sheets
Manipulatives as needed for individual problems:a cube,cards or counters for constructing an array, or for categorizing, (e.g. a packet of stamps of various issues and denominations,plus envelopes)

Strategies (to try)

1) Recognizing Patterns.
2) Simplify, substitute, reduce, round off...make it manageable.
3) Experiment, model, visualize.
4) Estimate: guess and test.
5) Organized Listing.
6) Deduction.
7) Algebra, Geometry skills.
8) Working Backwards: when the outcome is known and the initial conditions are needed.

Procedure: Discuss briefly what a "problem" is, (v. practice exercises); work through a few together with students modeling, e.g., form a human hexagon for #3 below.

Some sample problems are on accompanying handouts needed for illustration. Here are a few not needing a graphic to present.

1) To earn spending money, Roy bought some Indian Head pennies at 6 for $l0, then sold them at 4 for $10. His profit was $50. How many pennies did he buy and sell?

2) Find a number that when multiplied by 81 or divided into 6,561 gives the same answer.

3) Six students in Mrs. Collins' Math l0 class were seated around a hexagonal table.

The places have numbers in order beginning with one. At what number is the student sitting opposite number four?

4) On a cube, the three faces showing have numbers 42, 43, 46. All the faces are consecutive. What is the sum of the numbers on all the faces of the cube?

5) The mortar between bricks in a wall is mixed with one part lime, one part cement, five parts sand, and three parts water. How much lime is needed if 20 ounces of sand are to be used?

A few ideas to develop critical thinking:

Four colors to fill in the cells on a hexagon grid sheet. No color can be contiguous to itself. Have partners take turns on the same sheet after individuals find doing this easy.

Triangle Tic Tac Toe

Students construct various patterns, designs, plane figures with tiles or counters, then show what they have done to the class, reviewing properties of figures,etc.

Use found objects to illustrate plane and solid geometric ideas, distance, position, and related problems.

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Time

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Objective

1) Physically Handicapped (EMH) students will learn to tell time using a number chart.
2) Students will demonstrate their ability to tell time by using a clock.
3) Students will use this skill to follow a daily schedule.

Equipment and Materials

Paper Plates
Rounded Paper Fasteners
4 sheets of black construction paper
Pages 3 and 12 from System 80 Activity Book
Clock Faces
Number Chart (1-60)

Recommended Strategies

These students learned to count from 1 to 60. Emphasis was placed on numbers that are multiples of 5. These same numbers were placed on the chalkboard in numerical order. Demonstration of this skill was evaluated when the students learned to count by 5 using the Rote Method and placing the missing numbers in the square on the number sheet.

The second strategy lesson began with questions-"**How many of you can tell time? Who would like to learn to tell time?**" The students agreed that since they had learned to count up to 60 and to count by 5s up to 60, then it was now time to learn to tell time. Before the students could actually learn to tell time they had to make their own clocks. Each child was given a paper plate with a clock face pasted in the center. Multiples of 5s were written on the paper plate counterclockwise. These numbers are about half the size of the numbers on the clock. One short hand, one long hand and a round head paper fastener was given to each student. The students attached the hands to the clock.

The third lesson began by asking the students,"**How are these hands different?**" The students agreed that one was long and one was short. I explained to them that the short hand is the hour hand and it tells us what hour we are in. The long hand is the minute hand and it tells us how many minutes we are past the hour. The students were shown 3, 6, and 5 0'clock. I explained to them that there are two ways to write the same time. One way is with numbers only and the other way is with numbers and words. I wrote the following on the chalk board.

3:00	10:00	5:00	7:00
3 o'clock	10 o'clock	5 o'clock	7 o'clock

Two students were asked to come to the front of the room and face the class. I asked one student to show me 2:00 in the morning and the other student to show me 2:00 in the afternoon. The class agreed that the clocks looked the same. However, at 2:00 in the morning, they would be sleeping and at 2:00 in the afternoon they would be in school. I explained to them that 2:00 in the morning was written 2:00 A.M. and 2:00 in the afternoon was written 2:00 P.M. The students were asked to do page 3 to demonstrate how well they have learned to tell time to the hour.

I began strategy five by telling the students that today we are going to learn how to use the minute hand. I told the class that the smaller number on the paper plate was for the minute hand or large hand only. I wrote 7:45 on the chalkboard. The students were told to show that time on their clocks. I explained to the class that the short hand should be on 7 and the long hand should be on 45. Several other times were elicited from the class, such as the time that they went to bed, ate lunch and woke up. In order to demonstrate their ability as to how well this skill was mastered the students were asked to complete page 12 from their math books.

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Problem Solving

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Objective

The student will be able to solve word problems using addition, subtraction, multiplication or division.

Equipment and Materials

A play Grocery Store
Pencils
Paper
Magazines
Scissors
Pointer
Money
Ruler
Cash Register
Newspaper Ads

Recommended Strategy:

Discuss with your class when we solve problems in real life. We must decide what information we need in order to answer the question that is asked. Frequently we have a lot of information that we do not need and sometimes we do not have the information that we do need. Discuss different things we see and buy when we go to the grocery store. Set up a real grocery store in your classroom, attach prices to them. Have a student select three or four items for purchase. Have student give the total price of all items. Ask student how much change they would receive from $5. Ask student how much change they would receive from $10.I would extend the activity described above and ask student what they would buy for $5. Could they buy one of each item? two or more items? Have the students use grocery ads from the newspapers. Specify an amount of money they might have, say $20. Check several items and have them compute the total price and determine how much money they would have left. The student should make up word problems to exchange with other students. Give students card with number "Headlines" on them and have students make up word problems to go with them.

Ex. (75 + 65 + 35 = _____).

Procedures:

1. Read the problem carefully.
2. Picture in your mind what is happening.
3. What information is given.
4. What is the question?
5. Decide what arithmetic you will use. Do the arithmetic.
6. Answer the question.

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RATIOS

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Objectives:

The students are to examine models and compare their lengths numerically. The students will measure the models and will then calculate the length of the real size base on knowing what the scale of the model is.

Apparatus needed:

What is needed is models of real objects that are familiar to the student. I used models of the Space Shuttle (three models of different sizes) and "Matchbox" cars. This product has the scale written on the bottom of the car.

Recommended Strategy:

What I did was display the three models of the Space Shuttle. I asked questions about how to describe the models. I accept all answers but what I am looking for is a mathematical description such as "twice as large", "three times as big". I talked about numerical descriptions and how to write comparisons as ratios. I would take the ratio and write it in the form where the numerator is 1. I would then talk about scales and what they mean. What does it mean that 1 inch is to 88 inches.I would take the model of the car and knowing the scale of the model, project how big the car would be in reality. The students would then pace off the actual length, by counting the tiles on the floor in the classroom. Review with the students that the scale may be written in metric and not English units. The difference is that a scale based on metric system if it is written in English Units will result in a real figure that is much larger than the actual vehicle could be. The students need to have an understanding of what the actual size of the real object is. Most students know how large a car is, whereas they might not know what the actual size of a railroad engine is and its actual length.

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Learning ratios and proportions through scale drawings.

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Objectives:

To understand that a ratio is a comparison between two numbers.

To understand that a proportion is an equivalent relation between two ratios.

To understand that scale drawings are ratios.

Given the ratios, the children will be able to make a scale drawing of the classroom.

Apparatus Needed:

1/4" and 1/2" graph paper
yardsticks
a variety of large wall maps

Recommended Strategy:

Introduction:

Write the word **scale** and discuss different types of scales including those used for weight, temperature, and maps. Allow the children to come up with as many ideas as possible and write them on the board. Tell the children that you will be discussing scales on a map and that scales are **ratios**. To explain ratios, draw a set of 3 triangles and 4 squares. Explain that this is a ratio of three triangles to four squares which can be written as 3 to 4, 3:4, or 3/4. Give other examples of ratios then use the map as the final example. Discuss the map ratio which is the scale of the map. Ask how the ratio affects the size of the map. What would happen if the ratio were different? Try to show maps with other ratios.

Activity:

Divide the children into teams so that each team has a surface area to measure including the floor and the walls but not the ceiling. Each team must have two dimensions and be able to change the dimensions of the room in order to draw it on the 1/4" graph paper scale. It might be wise to demonstrate this before the teams begin working. When each team has completed, have them cut out their surface leaving 1/2" edges around all sides except that which is adjacent to the ceiling. Tape the walls and floors together creating a room model. The children might want to do furniture to scale given enough time. You might also include blackboards, bulletin boards, and wall outlets. Have the children repeat this procedure with 1/2" graph paper. Compare the difference between the two models and discuss the idea of proportion. Carrying the activity one step further convert the measurements of the room to metric and do the activity on centimeter paper.

Extended activities:

Using the different models, discuss volume of the room and whether or not the metric would be the same as or different from the standard measure. Use salt or sand to do volume measurements.

Have the children make an enlargement of a candy wrapper showing that a scale drawing can help to enlarge as well as make smaller. Divide the candy wrapper into 1/4" grids and then divide a large piece of white art paper into 3/4" or 1" grids. Have the children fill in one grid at a time using colored markers the same way it is done on the wrapper. Do the details first then the larger areas that might be all the same color. An M & M box is a good example of an easy object to work on.

Spaces, a book located in the SMILE math library, has another set of activities similar to the room scale drawing. It includes 2 cm graph paper and an activity to design a scale model veterinarian's office with an equipment list and their measurements. It's meant to be Xeroxed. (NOTE: As of 8/2000 **Spaces** by Peter Parnall was still available from amazon.com - ISBN 1562943367)

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Problem Solving

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Objectives:

Demonstrate some common ways problems can be solved
List some basic steps in problem solving
Suggest some useful strategies for solving word problems

Apparatus Needed:

Practice exercise sheet (Using Parts and Wholes with Word Problems) or a teacher-made ditto of word problems with multiple-choice answers. The choices should be listed as Add, Subtract, Multiply, and Divide.

Pencil

Recommended Strategy:

```
                  W          P
            --------------------------
 not        |           |            |
equal       |     +     |     -      |
            |           |            |
            --------------------------
            |           |     .      |
equal       |     X     |   -----    |
            |           |     .      |
            --------------------------
```

For each word problem, draw a decision square on the practice sheet of paper. A decision square is a square divided into four sections with one of the four operational signs in each section. See diagram above.

SAMPLE EXERCISE

Jill's hive contained 5 lbs. of honey. She removed 3 lbs. to sell. How many pounds of honey did she have left?

First, find the question the problem is asking. Then decide whether it is asking for a whole (W) or for a part of something (P). "How many pounds of honey did she have left?" is the question. It is asking for the part that is left after 3lbs. have been removed.

Next, using the information in the problem, determine whether the groups are "unequal" or "equal" in value to each other. Since, five pounds and three pounds are unequal amounts, the groups are unequal. Circle "P" and "Unequal" on the decision box. Put your index finger on the "P". Place your thumb on the word unequal. Move your finger down the square and your thumb across until they meet. In the case of this problem, subtraction is the operation that should be used to solve this problem.

Words such as "in all," "final," "total," and "together" indicate that whole values are being used. Words like "have left," and "have then" indicate that part values are being used. The word "each" suggest equal groups. When the numbers or quantities are different, unequal groups are present. Circle the word "subtract" on the answer sheet.

Part 2 of this strategy is to use the numbers and the correct operation from the decision box to solve the problem numerically. In this case 5-3=2. This activity is recommended for use in grades 6-9, however, it can be simplified for lower grades or to meet the needs of the individual.

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Ratio and Proportions

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Objectives

To read and write proportions
To identify the means and extremes of a proportion
To solve proportions
To solve problems using proportions
To make a scale drawing

Material Needed:

Overhead projector, transparencies, chalkboard, various samplings of appropriate materials, including worksheets, and scale drawings.

Procedure:

The teacher will open the session with a daily review of changing fractions to decimal and decimals to percents, from 1/1 to 1/5. The teacher will review the vocabulary (ratios, proportions, means, extremes, and scale drawings). Students will give definitions in their own words with an example. Teacher will then give several examples of ratios, soliciting verbal responses with examples from the class. This step is then repeated with proportions, extremes, and the mean. To determine if students have mastered the above concepts, they will complete a worksheet. The teacher will assign various students to do the even numbered problems at the board and those students seated will do the odd numbers. The class will orally discuss the problems and answers. The teacher will then give the class a model drawing of a house and boat. The house will be increased by a 1 to 3 ratio, and then decreased by a 3 to 2 ratio. The boat model will be increased by a 1 to 2.5 ratio. The teacher will then close the session with the verbal drill.

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From Hypothesis To Conclusion...Reading Maps To Understand Proofs

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Objectives:

1. The student will write directions to any given situation using a map.
2. The student will be able to fill in missing data for any given situation.
3. The student will understand the importance of diagrams while writing proofs.
4. The student will develop a tentative understanding of writing proofs.

Materials:

Maps and transparencies of:

1. CTA Bus Routes
2. State of Illinois
3. Chicago Distance Classic
4. Washington, D.C.

Strategy:

This mini teach is directed toward 10th grade students who will soon begin to write two column proofs. To understand the step by step method in writing a proof, students will use their map reading skills to give directions to various places of interest in cities like Chicago and Washington D.C. and also other places of interest in Illinois.

Students will rearrange their desks to form groups, each group containing four members. Four situations with maps will be given to each group, one situation at a time, in which they will write out the necessary directions. Group discussion of each situation will be approximately five minutes. Only after the first situation will the class come back together to discuss their set of directions. One student from each group will read their directions as I follow along on a map on the overhead projector. If other groups have the same directions we will move on. Otherwise, we will discuss the variety of ways a person can reach the same destination. The students will regroup and discuss the remaining situations which will be given to them in five minute intervals. Again, as a class we will discuss their outcomes.

Next activity the groups will work together filling in missing directions to a given situation. After five minutes, a class discussion will be held.

Lastly, together we will write a geometric proof. Emphasize the statements and reasons of a proof must contain any of the following:

1. a given

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2. a postulate
3. a theorem
4. a definition.
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Triangulation

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Objectives:
The student will learn the basics of how to perform and calculate triangulation

Materials:
1 small pizza box; 1 soda straw; 1 paper protractor; 1 straight pin, large head; some centimeter tape; some string; a stapler or masking tape; some super glue ("Krazy"); and 1 washer.

Strategy:
MAKE THE BOX: 1) Put box together as manufacturer intended. 2) Bend top backwards, at top crease. Staple under box, forming open end. 3) Fold side flaps up and staple near back (closed) end. 4) Punch hole in center of back (closed end), near bottom. 5) Glue protractor on inside bottom -- center protractor on eye hole. 6) Tie string to pin and eye hole. Length of string should be longer than half the length of the box. 7) Glue string to pin. 8) Stretch string and pin to sides of box, and mark on each side.

```
        |                  |
        |                  |
      A |                  | B
        |\                /|
        | \              / |
        |  \            /  |
        |   \          /   |
        |    \        /    |
        |     \      /     |
        |      \    /      |
        |       \  /       |
        |        \/        |
        --------------------
                 E
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9) Place centimeter tape from mark to mark. 10) Cut out side flaps back to centimeter tape, fold the remaining inside flaps around and tuck into back. 11) Measure the perpendicular distance from eye hole to tape and record this on the box. 12) Tape (glue) straw along back edge of box.

You need a baseline laid out in meters (or feet, or any unit -- even sidewalk squares). "Permanent" Magic Marker used on the sidewalk will disappear in less than 1 month.

Stand at some location on the baseline. (Record this location number.) Hold box level with hole in front of your eye, and edge parallel to baseline. Look toward object and place the pin in your line of sight. (You see pin and object in line with each other.) Record the number (on the cm tape) which is under the string. (Scale number 1.) Move a good distance along the baseline and repeat the sighting. (Location 2, scale 2).

Subtract the locations (=D Baseline) and the scales (=D Scale). The distance to the object =

$$\frac{\text{D Baseline}}{\text{D Scale}} \times \text{Length to tape}$$

Why does this work? We are making use of two "facts": 1) light goes in straight lines; and 2) similar triangles have proportional dimensions. So:

$$\frac{\text{D Scale}}{\text{Len to tape}} = \frac{\text{D Baseline}}{\text{Distance to object}}$$

The first triangle (the small one on the box) has a base along the tape (= D Scale) and an altitude (length to tape). The second triangle has a base along the baseline (= D Baseline) and an altitude (= distance to object sighted).

NOTE: It is not necessary that these be acute triangles. Obtuse triangles work just as well. You will be finding the distance, D, perpendicular to the baseline.

You will need a table of tangents. You may call for such a table or make one for yourself.

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CUISENAIRE RODS AND MATH

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OBJECTIVES:

1) To familiarize students with the history, development and philosophy of the Cuisenaire Rods.
2) To have students be able to find the least common multiple of several given numbers using cuisenaire rods.
3) To reinforce previously taught math skills by using cuisenaire rod games, puzzles and or activities.

MATERIALS:

1) Booklet with identifying information for each rod - color name, size and centimeter graph paper - for each person.
2) One set of cuisenaire rods for every two people.
3) Blank paper for making tables, keeping scores etc. - for each person.
4) A blank game board made from cardboard to help stabilize paper game boards while playing the various games - for each person.
5) Booklet of games - includes duplicated game boards and directions - for each person.
6) Overhead projector masters of each game in game booklet.
7) Overhead projector master of definitions used in lessons.
8) One set of overhead projector cuisenaire rods.

STRATEGY:

1) What? Explain to students that they are going to learn a new way to use the rods, but before doing so they will review some rod skills taught previously and use the rods to discover some things which will help them with the new skill to be taught.

2) Definitions: Trains - the result of putting rods together end to end (resembles how trains are hooked up). Other words defined during lesson are: least common multiple (L.C.M.), and multiple.

3) Concepts to be reviewed: a) Color names for each rod length. b) Letter symbols for each rod length. c) Showing basic addition, subtraction, multiplication and division using the rods. d) Writing simple equations with variables - using rods. e) Showing and naming fractional parts with the rods.

4) Patterns - Discovery game/activity The challenge - Students must find/discover all the trains equal in length to a particular color rod. These trains are the patterns for a particular color rod. The students must also write the equations for each pattern. There are 4 patterns for the green rod (g=g, w+r=g, r+w=g, and 3w=g) but the patterns become increasingly more difficult when you use longer rods. There are 512 patterns for the orange rod. Note: for an advanced student you may challenge them to predict how many patterns each rod will have and come up with a formula to get the results.

5) Finding the Least Common Multiple (L.C.M.) Students will use skills taught in prior lessons and the review session to begin learning about the L.C.M.. At the end of the lesson the student will be able to find the L.C.M. of 4 given numbers. Students will be told to make a purple train from a given number of rods and match it with the equivalent number of dark green rods. They will then find out what the length of these two trains is in white rods. The students will be asked to record their results on a table and look for patterns. The students should notice

that "the first time these two trains meet they are the same length as 12 rods. They should also notice that they meet again when they are the same length as 24, 2
36, 48,......whites. These are the common multiples of the two rods. Since the train of length 12 is the smallest common multiple it is called the least common multiple". Note: At the end of the lesson students will be allowed to play cuisenaire games from the game booklets given to them. The degree of difficulty of each game varies from simple to very complex. Many math and thinking skills are used and reinforced while playing these games.

6) Additional strategies, suggestions etc. from critique - none given.

Activities used for these lessons are from the Student Activity Cards kit for cuisenaire rods by Patricia Davidson, Arlene Fair and Grace Galton.

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Mathematics/Physics

Introduction To The Number Line

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Objectives:

The students will learn how to add and subtract using the number line with positive and negative numbers. The lesson is designed for third through ninth grades.

Materials:

Magnets that stick to the board.

Strategy:

First draw the positive side of the number line on the board. Point out the following; **0** is neither positive nor negative, a positive number is greater than **0**, and positive numbers are to the right of **0**. Begin by giving sample problems such as **(8 + 1 = 9)** to solve using the number line. Place the first magnet under the number eight, and then explain that the plus sign is telling you to move in the positive direction once, then place the second magnet where you ended, and that would be your answer (**9**). Show several examples with simple problems such as the one above. Make sure everybody understands this technique before moving on.

We can also show how to subtract using the positive number line **(8 - 1**), tell me what number should I place the magnet under? "Eight " Why? Because that is the first number in the problem, then explain that the subtraction sign means to take something away, therefore we need to move back one space to the number (**7**), and that would be our answer. We can now give the following rule: when adding two positive integers, the answer will be positive.

At this point draw the other half of the number line on the board, this side of the number line is for the negative numbers. The important points regarding the negative numbers are; **0** is neither positive nor negative, a negative number is less than **0**, and the negative numbers are to the left of zero. I would proceed by giving examples of adding with negative numbers. For example:

$$^{-}7 + {}^{-}2 = {}^{-}9$$

Place the first magnet under the number seven (negative), then explain that the plus sign is telling us to add two more negative integers, move two steps to the left of the number seven and that will give you the correct answer (**-9**). Give more examples of problems using negative numbers. The rule that applies here is: <u>when adding two negative integers the answer will be negative</u>.

There is one more piece to this puzzle and that is learning to subtract using unlike signs (positive and negative). For example:

$$\mathbf{7 - {}^{-}2 = 7 + 2 = 9.}$$

The rule is: <u>do the opposite of the sign number and change everything to posi</u>tive. The sign number is the second number in the problem **(-2)**; therefore we would change the subtraction sign to an addition sign and change the negative two **(-2)** to a positive two **(+2)**. You could also answer this problem using the number line.

We would begin at the number seven (place the magnet under the number), the subtraction sign is telling us to move two steps towards the origin (which is zero) but our sign number is telling us to do the opposite of that, move two steps further away from the origin beginning at the number seven **(+7)**, and that is how we arrived at the number **(+9)** for our answer.

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<u>Performance Assessment</u>:

I will have the class solve several problems using the number line. They will answer the problems on their papers and on the board.

<u>Conclusion</u>:

When you move in the negative direction on the number line, it does not mean that you are going backwards, but simply that you have changed direction.

Mathematics/Physics

Extending Our Knowledge of Place Value

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Objective(s):

This lesson is designed to reinforce the knowledge of place value for first and second graders. The objective is to strengthen the knowledge the student has of place value by using their auditory, visual, and/or kinesthetic learning styles. Use numbers 10-99 only.

Materials Needed:

Two students paired

Place value mats

Base 10 sticks

Ones cubes

Chalkboard/chalk

Strategy:

Kinesthetic learner: Pair students into twos. To count by tens have each child hold up five fingers on their right hand. One student merges his five fingers with his partners five fingers, then they hold them high up in the air. Tell them 5+5=10. [Explain that every time you hold up ten of anything this is called a set]. A set in place value will "only" contain 10 of whatever you are talking about.] Use this for numbers 10-19 only. Then call out any number between 11-19. The ones numbers are shown by using the left-over fingers. Example: The number 17 is called by the teacher. The students merge their right hand together to show one set of tens. One student will hold up 5 fingers and the other student will hold up 2 fingers. Have the students to hold up their merged hand and say 10. The student holding up 5 fingers should then say 11,12,13,14,15, and the other student says 16,17. Call 2-4 more numbers for reinforcement. Then call 20 and see if they hold up 2 sets of hands. To make this more challenging, call up 2 sets of students. Call out a number between 20-40.The number is 27. This time choose the way in which you make 7. Two students hold up 2 sets of tens while the 2nd set of students show the number 7. This time one student will hold up 4 fingers while the other student holds up 3 fingers. Continue in this manner.

Visual learner: Pair students into twos. Pass out place value mats, base 10 sticks, and ones cubes. This will be already placed in a quart sized baggies – 9 base 10 sticks, 9 ones cubes, and 1 place value mat. (A place value mat is a piece of paper with a line drawn vertically in the middle of the paper and the heading in the right column saying ones and the heading in the other column saying tens.) Hold up a base 10 stick and explain that this is a set-1 set of tens. Now, have them hold up 3 base 10 sticks. Tell them that this is 3 sets of tens. Have them count by tens and tell you how many sets of tens there are. They must be placed in the tens column. Call out several numbers in this manner so the student can get familiar with the word sets. Any of the ones cubes should be placed in the ones column. Clear your mat each time you call a new number.

Auditory learner: Pair students into twos. Follow the directions above for either of the learners listed. As you verbally give instructions have this student tell you what they are doing while they demonstrate it. Everything this learner does should be a show- and- tell. When you call a number out loud this student should be able to tell you what number is in the ones column and what number is in the tens column. The number is 59. Ask the student (always start with the ones column first) what number is in the ones column and what number is in the tens column. If any student has problems at this point, write the number on the board and draw a line between the 5 and 9. If the student still has trouble comprehending the concept, then write the word "ones" in the ones column and write the word "tens" in the tens column. Now ask the student what number is in the ones column and what number is in the tens column.

Performance Assessment:

The student will be able to: a.) hold up an adequate amount of fingers or b.) write the proper place value for a number or c.) tell you verbally how many tens and ones in a given number or d.) tell you how many sets of tens in a given number. The rubric is to successfully answer 2 out of 3 correctly using either methods a.) or b.) or c.) or d.)

References:

Early Intervention Program-Teachers Edition

Mathematics/Physics

Filling the Glass (Water, Air, and Fractions)

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Objective(s):

Appropriate for elementary-grade students who have a beginning knowledge of fractions and measuring. Students will associate the physical act of measuring a fraction of a given amount of water with the arithmetic operations involved. Each group will use a different method of measuring, and compare/contrast the associated equations with those produced by other groups. The lesson is intended to integrate science and mathematics.

Materials Needed:

Class:

(Note: All glassware must be transparent.)

2 identical straight-sided, flat-bottomed glasses (e.g., "Tom Collins"-style), 2 identical sloped- or curved-sided glasses (e.g., "rocks" or champagne glasses), 12 identical plastic glasses (any style), 2 graduated cylinders, 2 graduated beakers, 1 meter stick or 12-inch ruler, 1 roll masking tape (optional), 1 marking pen (optional), 1 balance-beam scale with weights, at least 3 liters of water (if water source is not handy), 1 clear glass bowl, 1 chalkboard/whiteboard/overhead projector (for the sake of brevity, we will refer to this as the "board").

Each group:

1 calculator, pens/pencils and paper for each member.

Strategy:

Divide class into groups of 3 or 4 members each and distribute group materials. Place class materials together on a table accessible and visible to all, and close to chalkboard/whiteboard/overhead projector. Begin by filling one of the straight-sided glasses with water. Ask the class to describe the glass using the words "full" and/or "empty." Ask them to do the same with the other straight-sided glass (at this point, it is better to do this silently on their own paper, since we are not ready to discuss this yet). Now call up one group and challenge them to move half the water from the first glass into the second. Most will simply pour back and forth until the water in both glasses is at the same level. If they start to reach for the measuring devices, ask them to explain the procedure they had in mind, discuss its merits, and challenge them to do it instead without measuring devices. Once this is done, discuss the concept of taking half of something and write "1/2 of a glass of water" on the board. Once again, ask the class to describe (on paper) the two glasses using "full" and/or "empty."

Now empty one of the glasses and challenge another group to move half the water from the other glass into it, this time using the ruler. Most will measure along the side of the glass to the level of the water and calculate half of that length (some may wish to use the masking tape and marker to mark levels). Point this out and ask someone from the group to write an equation on the board that describes what they just did. When they have written "1/2 X (measured length) = (result), ask them what the measure of a full glass would be. Some will go back and measure, others may say, "Just multiply by two," or something to that effect. Once again, have them represent this mathematically on the board. For the last time, ask the class to describe (on paper) the two glasses using "full" or "empty." Set aside the glass with water in it for later.

Send all students back to their seats and go to the board. Point to the original phrase and ask which of the things they wrote could replace the words "of" and "a glass of water." Is this an equation? (No). Referring to the various things on the board, and adding others as you go, guide them through an introduction to multiplying fractions times fractions and fractions times whole numbers.

Replace the glasses with a sloped- or curved-sided pair. Call up a third group and challenge them to fill one glass half-full of water. If they do so by pouring back and forth, point out that the resulting level may not be where they might have expected, and discuss why. Then ask them to perform the same task using the balance-beam (if this was their first instinct, do the water-level discussion when they finish). Would the ruler have worked this time? (No). Ask them to represent the procedure mathematically on the board, using the previous examples as a guide. Then, as before, empty the water from one glass and ask them to transfer half the water from the other glass into it. Once again, ask them to represent the procedure mathematically on the board.

Send this group back and call up the fourth group. Have them repeat the above procedure with either the graduated cylinders or beakers, explaining the reasons for their choice. When they have finished (including the math), send them back and engage in a general discussion about choosing most appropriate forms of measurement (eyeballing, length, weight, volume, etc.) as well as measurement tools.

As a wrap-up, take out the two straight–sided glasses and fill one with water. Ask the class how they responded when asked to describe it as "full" or "empty." Do the same with the other glass. Most will have said, "empty" for this one. Fill the glass bowl, upend the glass in it, and ask, "If the glass is empty, what is keeping the water out?" When they say, "air," talk about the importance of being specific (full of what?), relating to the fractions and equations on the board (1/2 of what quantity?). You may also want to discuss when it is and is not appropriate to treat fractions as abstractions, or describe Empedocles experiment confirming air as a substance (a good account may be found in the book Who's Afraid of Schroedinger's Cat?).

Performance Assessment:

Group assessment should be made on basis of cooperation and success in involving and communicating with the rest of the class. You may also want to consider success in mathematically describing their experimental activities. Individual assessment should be based on participation in group and whole-class discussion and activities.

References:

Who's Afraid of Schroedinger's Cat? (paperback published in 1998; sorry, I don't remember the author or publisher).

Mathematics/ Physics

Having Fun Working With Fractions

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Objective(s):

Model each addition and subtraction example by shading parts of each region

Divide a word into appropriate fractional parts

Pay attention to details in instruction relating to " first", " last", "second", etc.

Analyze clues and decode the message

Use standard algorithms for addition, subtraction, multiplication, and division of fractions

Materials Needed:

15 12 in. by 12 in. Dry Erase Boards (If not applicable you may have the students section off the chalkboard into square regions)

1 Dry erase markers (two different colors)

1 Ruler

1 Game Board (Pre-made)

1 Pair of dice

5 Game pieces

1 Calculator

1 Mars candy bar

Strategy:

Station #1 "Fractional Parts"

Students will use their dry erase boards to model five problems using addition and subtraction of fractions from off the board by shading parts of each region. Using one of the color markers to shade the parts. (See section for materials needed.)

Station #2 "Mars Fraction Hunt"

Students will write the appropriate parts of the words on the line to form a new word. When the message is complete, the first student to decode the message will be rewarded with a Mars candy bar. Ex.) The first half of food + the last quarter of door and the answer will be the first half of fo/od = fo and the last quarter of doo/r = r makes the new word for.

Station #3 "Mir Mission To Mars Game Using Fractions"

Teacher will create a board game making a path from Earth to Mars using around 30 to 40 spaces between the two planets. The teacher will use index cards for the three decks needed for the game. The first deck will be called "Danger" these cards are used to make the players either lose a turn, go back to Earth, or go back a specific amount of spaces. The second deck will be called "Warp Drive 1" consisting of problems where the players will have to answer easier problems consisting of addition, subtraction, multiplication, and division of fractions. The third deck will be called "Warp Drive 2" which will be made up of more difficult problems using fractions. This game is designed to be use as a cumulative activity on the students understanding of addition, subtraction, multiplication, and division of fractions. It is intended for 6, 7, and 8 graders but can be modified for the lower grades by changing the difficulty of the questions on the cards to fit your specific grade level.

Directions:

1.) Each player rolls the dice to determine who goes first. The person with the highest number goes first, the play continues clockwise.

2.) The first player takes a card from either Warp Drive 1 stack or the Warp Drive 2 stack of cards.

3.) If the player answers the question/problem correctly, he/she will then roll the dice.

4.) The number rolled is the number of spaces the player may advance on the board.

5.) If the player answers the question incorrectly, they do not move, nor do they roll the dice.

6.) If a player lands on "Danger", he/she must take a card from the "Danger" stack and follow the instructions written on it.

7.) Play continues until all players have landed on Mars. The first one to reach Mars is the winner!!

Performance Assessment:

Ongoing assessment throughout the game based on the students' ability to answer a percentage of questions correctly.

Number Addition Race

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Objective:

This lesson is designed to help students with addition.
Students will solve word problems relevant to their experiences that involve addition.
Students will participate in a game involving addition using the phenomenological approach.

Materials:

Dry wall tape (available at hardware stores)
Paper and pencil - scissors
Metric ruler - meter stick
Random number generator - dice or spinners

Strategy:

Divide students into groups of four. Each group will need the materials listed above. Long tables or six to eight desks arranged into a rectangle make the play area. Two students on one side of the table compete with two students on the opposite side of the table. The first pair of students generate the first number for an addition problem. Write the addend on paper. The second pair of students will use a meter stick to measure the addend in centimeters on the drywall tape. Write the measurement on the drywall tape. The first pair of students will generate a second addend and write the number under the previous addend. The second pair of students will measure this amount on the same strip of drywall tape adjacent to the first measurement. Write the measurement on the drywall tape. The first pair of students adds the addends to find the sum while the second pair cuts the drywall tape and measures the total length of the strip. THE MEASURE OF THE DRYWALL TAPE SHOULD EQUAL THE SUM OF THE ADDENDS. If the drywall strip is measured correctly and the addition problem is correct, then the first pair of students receives the strip (tape drywall strip to the table starting at the edge of the table). Play continues with the second pair of students generating the addends for the addition problem and the other students measuring the addends on the drywall tape. The first pair of students to line the length of the table with the drywall tape is the winner. This activity can be adapted to practice fractions and decimals.

Performance Assessment:

Students verify the addition problem by measuring the addends on the drywall tape and matching the total length of the drywall with the sum of the addition problem. If the students made a mistake in addition the other side will keep the drywall measurement and tape it to their side of the table. Students will lose a turn if they incorrectly measure the drywall tape.

Acknowledgement:

David Drymiller, a member of the SMILE staff has been very helpful with his expertise and sharing his own personal materials.

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Lesson for Multiplying and Dividing Fractions with Post It Notes

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Objectives:

Students will use postit notes to measure various dimensions of rectangles to nearest fraction of an inch. This lesson is intended for seventh grade. Students will divide fractions to predict the number of postits needed to meet the length and width of the rectangles.

Materials Needed:

3 by 3 inch postit notes
1 1/2 by 2 inch postit notes
different sized rectangular shaped paper
rulers and yardsticks

Strategy:

Show students a piece of 8 1/2 by 11 inch piece of paper. Ask students how many postit notes it would take to meet the length and width of the piece of paper of each size. Explain the algorithm for dividing fractions to see mathematically how many 3 by 3 postits will fit and how many 1 1/2 by 2 will fit. To illustrate this, divide 8 1/2 by 3. You get 2 5/6. Take the 3 by 3 postit notes and place them along the 8 1/2 side of the paper. Carefully cut the overlapping part of the last postit note. Measure the part remaining on the paper and it should be close to 5/6 of 3 or 2 1/2. Measure the part you cut and it should be 1/2. Do the same procedure with the other dimension of the 8 1/2 by 11 paper by dividing 11 by 3. Place the postit notes along the 11 inch side and verify the math. Then do the same with 1 1/2 by 2 inch post it notes. After finishing this demonstration, pass out two different size rectangular sheets of paper and have students measure the sides. Working in groups, have students determine mathematically how many of each kind of postit notes it would take to cover both dimensions of both sheets. The students, after doing the math, will then tell you how many postit notes they need. Give them exactly what they ask for and have them cut out the fractional part of the post it note they need by measuring it first. Display the student's work on the board and discuss strategies for finding the answer and ways the answer could go wrong. Precise measurement is very important for accurate results.

Performance Assessment:

This activity in itself is a wonderful performance assessment. You may modify the sizes of the rectangles or simply use straight lines.

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Adding Mixed Numbers with Unlike Denominators

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Objective:

This is a seventh grade activity designed to provide students with practice in adding mixed fractions with unlike denominators.

Materials:

tape measures; water soluble marking pens; 12 inch rulers; teacher made block letters of equal height but widths containing fractional parts including 1/16, 1/8, 1/4, 1/3, 1/2 (or any fractional part that can be measured by using a 12 inch ruler); long strips of fadeless paper or a roll of drywall tape; scissors; glue

Strategy:

Review addition with mixed numbers, first at the board, then at the desk using individual worksheets. When seatwork is complete pair the students. Using a tape measure, each student will measure distance from his/her wrist to the tip of the longest finger. Make a dot, with the marker, at that spot on the wrist where the measurement began. Record the distance. Next, measure the distance from the spot on the wrist to the inside fold in the arm where the forearm and upper arm meet. Put a dot on that spot in the fold. Record that distance. Measure the distance from the inside fold in the arm to the shoulder joint. Record it. Sum the three measurements. Measure the distance from the shoulder joint to the inside fold in the arm. Compare the added length to the measured length.

In the second activity students will select the precut letters to form such things as school name, first name or nickname. Students will measure the width of each letter, allocate 1/4 of an inch space between each letter, and then add all letter widths and spaces. Once the students have calculated the width of letters and spaces they will cut fadeless paper or drywall tape to equal the width of the calculated letters and spaces. Paste the letters onto the fadeless paper or drywall tape.

Performance Assessment:

In the first activity, if the students have measured and added correctly, the sum of the three measurements should equal the distance measured from shoulder joint to finger tip. In the second activity, the length of the fadeless paper or drywall tape should be equal to the sum of the letters and spaces. Both activities are self checking.

Grading Rubric

If the error in measurement is within 1/4 of an inch a grade of A should be awarded. If the error in measurement is within 1/2 of an inch a grade of B should be awarded. If the error in measurement is within 1 inch a grade of C should be awarded. If the error in measurement is within 1 1/2 of an inch a grade of D should be awarded. If the error in measurement is greater the activity should be redone.

Conclusions:

This activity enables the student to put math concepts to practical use. It also motivates the student to measure correctly. Finally, the self-checking mechanism makes the activities easy to grade.

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Multiplication

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Objective:

Perform basic computations using the operation multiplication.
Use the operation to evaluate expressions involving whole numbers and decimals.

Materials Needed:

Electronic Scale - Measurement of grams and ounces
6-8 Manipulatives of different weights - ex. small foam circles, rubber bands, paper clips, dimes, beans, small craft beads.
Charts to enter weights

Strategy:

We began by reviewing some multiplication facts. We defined factors, products, multiplying by one and two digit factors. A basic review of multiplication of decimals would be helpful to the students. We began by writing the weights of one of each of the manipulatives to be weighed. For example 1 rubber band weighs 0.7 grams. The student will be given a list of numbers to then multiply and calculate the different weights. For example: what is the weight of 6 rubber bands 10,17, 51 etc. The student would then weigh the number of rubber bands on the electronic scale to see if their calculations were correct. The weight of 27 rubber bands multiplied out manually would be 27 times 0.7 =18.9. The weight of 27 rubber bands on the electronic scale is 18.8. There will always be some difference in the weights, the bands are not exactly uniform.

Performance Assessment:

Evaluation would consist of comparing the results of the manual multiplication to the weights from the electronic scale. This would be the case for each of the manipulatives. If the students multiplication is correct the comparisons should be close.

Conclusions:

The items being weighed are in grams and ounces. It is advised that a number of the items be weighed together and divided by that number to get an accurate account of the weight of one item.

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Putting the Pieces Together (Making a Fractional Quilt)

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Objectives:

* Demonstrate a phenomenological approach to teaching fractions.

* This lesson is designed to motivate students to develop a sense of equivalent fractions.

* To explore addition of fractions with unlike denominators.

* Students will be able to divide a whole number into specified equal parts.

Materials Needed:

(1) 1 large cardboard backing that will accommodate approx. (20) 9"x12" poster boards or felt

(2) 20 multicolor 9"x12" poster boards or multicolor felt

(3) glue or needles and thread (depending if you are gluing or sewing your quilt)

(4) scissors

(5) sturdy backing for each 9"x12" poster board

(6) paper clips/straight pens (optional)

(7) (20) 3.5" blocks of paper (small swatches)

Strategy:

Students are given small paper swatches with a designated number on the back. Each student is required to cut their 9"x12" poster board into blocks or horizontal equal fractional pieces that will represent the number on their swatch, i.e., if the number is 6, the students will cut their 9"x12" poster board into 6 equal parts. The paper must be positioned, so that the cut is held in the 9 inch position. Label each piece 1/6.

Challenge students to use their rulers or any measureable tool to cut their strips or blocks into equal amount of pieces, that represents the number on their swatch. Forbid folding the paper. Encourage students to cut their paper into blocks and/or strips.

Group students according to the number on the back of their small swatch.
Recommended grouping:

2	3	4	5	6
4	6	8	10	12

```
                              |   8  |  9  | 12  | 15 |  18 |
                              |  10  | 12  | 16  | 20 |  24 |
```

Assemble students into groups of 4's. Students will compile their pieces into one pile. Students will take turns picking pieces from the pile. Students will combine their fractional pieces, adding their fractions, and making sure that when all of their pieces are in place, their 9"x12" replica will equal one whole. For example, if a student select the following pieces; 1/4, 1/16, 1/16, 1/16, 1/16, 1/16, 1/8, 1/8 add.

$$\frac{1}{4} = \frac{10}{40}$$

$$\frac{5}{10} = \frac{20}{40}$$

$$\frac{2}{8} = \frac{10}{40}$$

$$\frac{40}{40} = 1$$

Each group will make up to four different configurations (patterns). Students will paste their design on a sturdy 9"x12" poster board, for the backing. If felt is used, allow students to sew the pieces together, or have them glue the pieces on the 9"x12" sturdy poster board.

Collect all finished quilt pieces. Place each 9"x12" on large canvas or whatever you are using to display your quilt. Remember you will need a canvas that will accommodate approximately (20) 9"x12" poster boards.

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"Factors"

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Objectives:

Demonstrate a phenomenological approach to teaching mathematics

Inspire others to use the approach

Objectives (Grades 5-7):

Show and record groups formed by using pennies

Define factor, product, prime, and composite

Write related number sentences

Find the factors of whole numbers

Classify numbers as prime or composite

Identify abundant, deficient, and perfect numbers

Materials Needed:

paper coins (actual coins??)

worksheet for analyzing first moves

Recommended Strategy:

Ask: "How many ways can you make change for $1.00 using only groups of the same coin?"

```
Expected responses:  1 group of 100 pennies
                    20 groups of nickels
                    10 groups of dimes
                     4 groups of quarters
                     2 groups of half-dollars
```

"How many ways can you make equal groups of 100 pennies?"

```
Expected responses:  1 group  of 100 pennies
                     2 groups of  50 pennies
                     4 groups of  25 pennies
                    10 groups of  10 pennies
                    20 groups of   5 pennies
```

Discuss similarities in responses to both questions

Show one penny - Write "1 group of 1 = 1"

Show two pennies - Write "1 group of 2 = 2"

Show three pennies - Write "1 group of 3 = 3"

Show four pennies - Write "1 group of 4 = 4"

Show two groups of two pennies - Write "2 groups of 2 = 4"

Show and record all equal groups for 5 to 12 pennies

Write number sentences: 1 x 1 = 1; 1 x 2 = 2; 1 x 3 = 3; 1 x 4 = 4;
2 x 2 = 4; 1 x 5 = 5; 1 x 6 = 6; 2 x 3 = 6;
... 1 x 12 = 12; 2 x 6 = 12; 3 x 4 = 12

Define factor and product

Analyze number of factors for products 1 - 12

Identify and define prime and composite numbers for products 1 - 20

Play "Factor Game" - List the numbers 1 - 36 as a 6 x 6 grid. Circle a number. Students draw a box around each proper factor of the number. Students select a number and draw a box around it. Teacher circles proper factors of the number. Continue process until no moves are possible. Add the teacher's and students' numbers. The highest total wins.

Analyze first moves for the factor game - List the factors for numbers 1 - 36. Compare the sum of the proper factors to each number.

Define abundant, deficient, and perfect numbers

Performance Assessment:

Select a two-digit number greater than 50.
Identify its factors.
Write related number sentences using the factors and the number.
Explain why the number is prime or composite.

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Place Value

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Objectives:

Students will be able to identify the value of numerals through 10 digit numerals.

Materials Needed:

-blackboard
-chalk
-notebook paper
-monopoly money
-prizes

Strategy:

The strategy will incorporate cooperative learning, direct teaching techniques and a phenomenological approach to mathematics. The direct teaching method explains the objectives and how to identify the value of numerals through ten digit numerals. Cooperative learning encourages the students to interact to formulate the correct answers. The Phenomenological approach challenges the students' problem-solving skills.

Direct teaching techniques: A short lecture is given on how to identify the values of numerals through ten digit numerals underlined. Students will have to identify the place value of the numerals (20 problems); for example, 6,**4**56. The digit which is underlined is located in the hundreds column. A short lecture is given to the class on how place value is used in America. The class will participate in an auction. Each student is given ones, tens, twenties, fifties, and hundreds. The last step involves the students bidding on prizes. The highest bidder wins the prize. The winner must explain accurately what column each digit represents.

Cooperative Learning/Phenomenological Approach: The students will form two groups and will be given one numeral from 0-9. The place value will be called orally. The students must line up in direct place value order holding their numerals; for example, the instructor calls out the number four hundred and twenty six. The first three students who line up in order from right to left using ones, tens, and hundreds wins. The first student holds the number six. The second student holds the number two, which represents the tens column. The third student holds the number four, which represents the hundreds column.

Performance Assessment:

Students will be able to identify place values of the underlined number from ones to the millions (20 examples on a worksheet).
Students will be able to form numbers from ones to millions using cards.

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Percentages

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Objectives:

To introduce 5th and 6th grade students to percents.
To demonstrate to students how to change fractions to decimals.
To show students how to change decimals to percents.

Materials Needed:

Colored tape, pencils and worksheets.

Strategy:

This lesson will consist of 100 squares that will be measured within one classroom. The students will also be broken up into different groups so they can measure the section of the science lab independently. The students will give the total number of floor tiles counted to a recorder in each group so that each group can find the percentage of each area in the science lab.

Performance Assessment:

The students will be able to recognize a certain percentage, to convert the fraction into a percent, and percent into a decimal.
Students will be given worksheets, so they can determine the ratio of each given fraction and vice-versa.

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Counting and Place Value

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Objective:

The objective of this lesson is to give first grade students a concrete understanding of place value by providing concrete opportunities to use place value to practice counting, adding and subtracting using a phenomenological approach.

Materials Needed:

- interlocking cubes
- bell
- place value boards
- number flips
- small and medium sized containers
- containers of various objects:
  - pencils
  - Pokeno chips
  - beans
  - straws
- strips of adding machine paper

Strategy:

Review numbers 0-9 and have the students practice counting various objects in the classroom from 1 to 9. Leave the numbers on the board where the students can see them.

Give each student a place value board. The board may be constructed of poster board or construction paper. The left side of the place value board (referred to as the PVB in the remainder of this paper) is blue. The right side is white.

Explain how to read the PVB. Ask the students what is on the board. When they respond that there is nothing on the board, ask them the number word for nothing. After they say "zero" tell them to read the board zero and zero, which means that there is nothing on the left (blue) side of the PVB and nothing on the right (white) side. Remind the students that we will read the PVB the same way we read a book, that is, from left to right.

Next show the students the bell. The ringing of the bell one time means add one cube to the PVB. We always place a single cube on the right side of the PVB. This side of the board is called the ones' column. Have students practice adding a cube each time the bell rings. Have them read their boards each time a cube is placed on the board. When they have nine cubes on the white side of their boards, explain that ONLY 9 cubes can go in that column. Ring the bell and ask students what they will do now. Help them come to the conclusion that they will put the cubes on the blue side of the PVB after they interlock them. These 10 cubes make up one ten. Tens are placed on the blue side of the board which is called the tens' column.

Continue the procedure of ringing the bell, allowing students to add cubes and read their boards until they appear comfortable with the routine. Next, introduce the connecting step. Students will use number flips to show the number symbol that corresponds with the number of objects shown on the board.

It goes like this: Teacher: (rings bell one time)
Student: (adds one cube)
Teacher: "Flip" (indicating to flip to correct number)
Student: (flips to correct number symbol)
Teacher: "Read"
Student: "Zero tens and one"

After the students add to 9 tens and 9 ones, they can practice subtracting the cubes in the same manner described above. When no single cubes are available the students will use a ten from the blue side of the PVB, take it apart to subtract a single cube and leave the nine remaining cubes on the white side of their PVB.

The final step involves recording what has been practiced. Give each student a strip of adding machine paper that has been folded in half vertically. Clear the boards and start the adding procedure again. After the students add, flip, and read, have one student at a time put a PVB on the floor showing the number that was constructed. The boards should line up from top to bottom. After every student has had the opportunity to put a PVB on the floor, show them how to write the numbers that show on their boards. Copy the numbers showing on the boards on the strips of paper, putting the ones on the right side of the fold and the tens on the left, and underline each number as follows: **00**, **01**, **02** and so on.

To extend the concept of place value, give the students many different concrete objects to count on the PVB. For example, beans can be used instead of inter-locking cubes. Each time ten beans are counted, they can be placed in a small container before placing them in the tens' column. Eventually the 10 small cups filled with 10 beans will be placed in a medium sized container and put in a third column called the hundreds' column. Two overlapping PVBs will provide this third column. Instead of cubes and beans, students may practice with Pokeno chips, straws, pencils, coins and many other objects.

Performance Assessment:

Students will be able to demonstrate, on a PVB, numbers up to 9 tens and 9 ones successfully. They will be able to read and/or write the numbers from 00 to 99, indicating that 1 ten and 1 is the same as eleven, 1 ten and 2 is the same as twelve, etc.

Conclusions:

The procedure described can be extended to the hundreds, thousands, etc. for higher grade levels. It can also be helpful in working with money concepts.

References:

Mathematics Their Way by Mary Baratta-Lorton

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Ratio and Proportion

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Objectives:

The students will use the phenomenological approach to complete the activities, calculate ratios and proportions and compare and contrast group data with class data.

Materials Needed:

Four 16 oz. bags of candy
Rice (2 different amounts of the same brand)
Cereal (2 different amounts of the same brand)
Tuna (2 different amounts of the same brand)
Canned Corn (2 different amounts of the same brand)
Gum (2 different amounts of the same brand)
Canned beans (2 different amounts of the same brand)
6 sets of 10 ratio cards with easily identifiable items to be compared (For example: girls to boys)
Timer

Strategy:

Review the definition of a ratio. Ask the students to write the number of vowel letters and consonant letters in their name as a ratio of vowels to consonants on a sheet of paper. Ask three or four students to come to the board and write their name and the ratio of vowels to consonants.

Divide the class into groups of five. Give each group ten ratio cards. Explain the directions and set the timer for five minutes. After the elapsed time, tell the students to stop. Ask one student from each group to write the group data on the board. Have the students line up on opposite sides of the room according to the ratio. For example, if the students identify the ratio of boys to girls, then the girls will line up in the front of the room and the boys will line up in the back of the room. Have one student count the number of boys and girls and check the answer on the board to make sure that it corresponds to the numbers counted.

Review the definition of proportion. Give each group a bag containing at least 10 pieces of candy. Clearly mark or label the price of the bag of candy. Ask the students to find the cost of one piece of candy. Have a student from each group record the group data on the board. Ask a member of each group to orally state the unit price of one piece of candy in the bag of the group. Ask the class to determine if the data written on the board is correct.

Give each group two different amounts of the same product. Ask the students to determine the cost of one ounce of each product and the best buy. Select one member of each group to write the group data on the board. Ask a member of each group to explain the data written on the board for that group. Have the class check the data written on the board.

Performance Assessment:

Give each group two different amounts of another product. Ask the group to determine the cost of one ounce of the product and the best buy.

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Introduction to Fractions Using Cuisenaire Rods

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Objective(s): Grade 5

(1) Students will visually "see" and manipulate fractions with Cuisenaire Rods staircase to develop concept and fractional relationships.
(2) Students will learn numerical values of rods and relate them to color and length.
(3) Students will use varied approaches to discovering new fractional relationships that answer the "why" in fractions and lessen "the only one way" hazard.
(4) Students will write a problem-solving story that is interest-based but also demonstrates basic understanding of fractions and vocabulary usage.
(5) Students will relate fractions in a relevant way to their culture.

Materials Needed:

(1) Cuisenaire Rods - One set per student
(2) Overhead Projector - Class
(3) Overhead Cuisenaire Rods - 1 set per class
(4) Acetate Sheets - 6 per class
(5) Grease Pens - Two per class
(6) Poster Boards - One per five groups
(7) Magic Markers - One per five groups
(8) Worksheets (2) - Two per student

Strategy:

(1) Display objects and discuss why fractions are important and needed in real-life situations, i.e. sewing, fabric measurement, money, recipes, telling time, body measurements, etc.
(2) Students will work in cooperative groups (A-E) and build a rod staircase.
(3) Students will explore, examine and learn the colors, lengths and numerical value of each rod.
(4) Students and teacher work together using the Overhead Projector with Cuisenaire Rods to develop and write fractional equivalents and relationships.
(5) Learners will make values of ten using each of the colored rods.
(6) Students will do multiples of the white, red and light green rods.
(7) Display an orange rod and show that it takes two yellow rods to make an orange rod. Write in the following manner:
O = 2 Yellow
1/2 O = Y
(8) Do the same with the Red (R), Dark Green (D), and Brown (N) which are multiples of two.
(9) Students discover the multiples of three, i.e. E=3G read as Blue

equals three Green, 1/3 E=G.

(10) Students will do a self checking worksheet to answer a Cuisenaire Rod riddle.

(11) Students will form cooperative groups (A-E) to write a mathematical story for a specific combination of Cuisenaire Rods displayed on the Overhead Projector.

References:

Using the Cuisenaire Rods, A Photo Text Guide for Teachers - Jessica Davidson
Cuisenaire Company of America, 12 Church Street, New Rochelle, NY 10805

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Measuring Mixed Numbers

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Objectives:

Grade 5

- -Students will discover the need and every day use of mixed numbers.
- -Students will measure different lengths to the nearest fraction of an inch.
- -Students will review the equivalent values of fractions (for example: 2/4=1/2).
- -Students will review how to come up with the common denominator and why.
- -Students will add mixed numbers phenominologically and then algorithmically.

Materials Needed:

- -1 pair of scissors per student
- -1 ruler per student
- -5 pieces of tape per student
- -1 worksheet per student
- -1 piece of scratch paper per student
- -Construction paper of different colors
- -Large clear container with graduated cups
- -Measuring cup set
- -Bucket full of milky water (mix in a little corn starch)

Strategy:

1. Before class, use your construction paper to make a couple sets of fraction bar charts (be sure to include whole, halves, fourths, eighths, and sixteenths). Use different colors for each different fraction length, and make your pieces board size.
2. If you have a large container that does not have graduated cups, just place a strip of tape down one side of the container, then pour a cup of water in at a time and mark the level for each cup on the piece of tape.
3. Create a worksheet that has about 4 different problems similar to the example below. Draw different length bars that the students will have to measure individually, cut out, connect, and then remeasure as a whole unit. They will only be measuring the length of these rectangles or bars which should be at various lengths between 1/2 an inch and 5 inches. This is a sketchy example of what one problem would look like:

Measure these lengths as accurately as you can, then cut them out, tape them together and remeasure the length of these two together:

```
`ffffffffffffffffffffffffp            `ffffffffffffffp
w                        w            w              w
w                        w      +     w              w   =
w                        w            w              w
afffffffffffffffffffffffq             affffffffffffffq
```

4. Begin the class with this question: "Pretend you are a zookeeper and your responsibility is to feed the baby animals their formula each day. The baby porcupine eats 2 1/2 cups of formula, the baby seal eats 5 1/4 cups, and the baby ape eats 7 3/4 cups. How much baby formula do you need to make to feed all three of the baby animals?"

5. Allow the class time to reflect on the problem and then explain that they are going to need to understand how to add mixed numbers in order to solve this problem. Demonstrate for them briefly on the board how they are going to use the worksheet. They are to measure the length of each bar and write that length inside the figure. Then they are to cut out each bar and connect them with tape onto the piece of scratch paper they have been given. They should now have a longer bar which they are to measure and write down the total length of the two bars combined.

6. When they have completed this worksheet go back and compare some of their answers. Then using the fraction pieces which you will have taped up on the board, show them the different lengths. If they measured 3 1/2 inches for one bar, show them 3 1/2 in fraction pieces. If their second bar was 1 1/4 inches long, then show them 1 1/4 in fractions. Demonstrate for them how to add those two fractions of different denominators (1/4 and 1/2) by replacing the 1/2 fraction piece with two 1/4 pieces and finding their length to remain the same. Using the fraction pieces, continue to visualize for them how we come up with a common denominator when adding fractions of unlike denominators.

7. When you feel they have grasped this concept, you then go back to your original question about feeding the baby animals. This time have them find the common denominator between 1/2 and 1/4 and then add their mixed numbers together to get the total amount of baby formula needed.

8. Finally, to prove whether or not the answer they got on the baby formula was correct, have someone come up and measure out the amount of cups fed each baby animal. Have them take the milky water (water and a little corn starch) out of the bucket and carefully pour it into your graduated, clear container. The amount of formula that is now in the container should be the same as the amount of cups the class came up with on paper.

Conclusion:

The students visualize adding mixed numbers physically by adding different lengths together to the nearest fraction of an inch and by adding cups together. Then they discover the simplified algorithmic process which reduces the amount of work they need to do. However now they also understand why they need to add mixed numbers and what mixed numbers are. In conclusion, their performance should improve greatly as they comprehend the usefulness of these skills and what it is that they are actually doing when they come up with a common denominator and add their mixed numbers together.

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A "New Set of Numbers" (An Introduction of Integers)

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Objective:

Students of the sixth grade will be able to add and subtract positive and negative integers. Incidentally, negative numbers were invented by the Chinese.

Materials Needed:

Group of fifteen students
Numbers with positive signs (written on construction paper)
Numbers with negative signs (written on construction paper)
A large zero (written on construction paper)

Two paper bags (one labeled positive and one labeled negative) with directions inside which tell the students what to do on the number line. Some examples are:

Take 3 negative steps	Add negative 3
Take 5 positive steps	Subtract positive 4

Strategies:

Review of number line on chalkboard:
Number line will be made, using students as the numbers. Students to the right of the zero will be called positive integers and all students to the left of the zero will be called negative integers. The distance from the zero to the next point (going in either direction) will be called the "unit distance." Each student will tell how many units they are from zero. The students will now receive their signed numbers written on construction paper.
The "additive inverse" concept will now be introduced and explained. The students will then find their additive inverse.
Students will move a given number of units (to the left or to the right) to represent the process of adding and subtracting integers. They will then name their new value.
Students will now pull directions from a bag and each take turns moving in the given direction; Ex: Take 2 positive steps.
Students will be given a sheet of problems to practice adding and subtracting integers.

Performance Assessment:

Students will solve a puzzle by adding and subtracting integers.

Conclusion:

After presenting this lesson, students will have a greater understanding of integers and the concept of positive and negative numbers. They will also know how to add and subtract integers.

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Primary Understanding and Use of Place Value

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Objectives:

1. To give students an awareness of some of the peoples that have contributed to the development of modern arithmetic. (Number systems)
2. To help students gain a better understanding of our base 10 number system and its application to real life problems.
3. To increase a student's ability to add and subtract two numbers having as many as three digits and involving renaming in the ones place and in the tens place.

Materials Needed:

Place Value board
Base ten blocks
Chip-trading boards
Chips (4 colors)
Dice
Activity sheets
Number Wheel Response Cards (Optional)
Multicultural materials

Strategy:

1. Discuss with the children some of the number systems used by other peoples such as the Romans, Egyptians and Mayas. Roman Numerals contain a symbol for one (I), five (V), ten (X), fifty (L), one hundred (C), five hundred (D) and one thousand (M). It lacks a symbol for zero and place value. Explain that Egyptian numerals are base ten as are our Hindu-Arabic numerals and are additive. The Egyptian numerials are usually written from right to left, do not use place value and the symbols used to write their numbers are called hieroglyphics. Mayan numerals are base 20, with place value and a zero place-holder. The increasing powers of 20 go up vertically instead of horizontally.

2. Put two Roman numerals on the board such as CX (110) and XLV (45). Ask children, "How did the Romans add?" As they see the problems encountered in doing this, lead the discussion to an explanation of our base 10 system and its advantages, the 10 symbols used are called digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9) and how the groupings by tens form a place value system. It is, therefore, possible to represent any number using only the ten basic symbols (digits). The position of each digit in the numeral determines the value of that digit. This makes the task of doing arithmetic operations much easier than in systems like the Romans or Egyptians.

3. Using a place-value chart showing ones, tens, hundreds and thousands, model with base ten blocks four problems -- the addition of two 3 digit numbers with and without regrouping and two subtraction problems up to 3 digits with and without regrouping. At the same time of modeling and solving the problems, have a student at the board showing abstractly what is being done as it is being modeled. This will enable the student to transfer what he sees concretely to the abstract. Be sure to stress that the largest digit each place value can have is a nine and that exchanges must be made for numbers larger than nine.

4. Give students experience in renaming or making exchanges by playing "Chip Trading". Give each student a playing board made from 8 x 11 inch manila paper marked in four vertical columns. At the top of the left-hand column, paste a small rectangular piece of black construction paper, red at the top of the next column, then blue and white. Cut out circles of these same colors and use for chips -- white representing ones, blue representing tens, red representing hundreds, and black thousands.

Children play in groups of two to four. Each player throws the dice in turn and always takes the number of white chips corresponding to the sum of the numbers shown on the dice. Using 10 as the number (or base) for making exchanges, whenever a player has 10 or more chips of one color, a trade must be made. (10 whites are traded for 1 blue; 10 blue for 1 red; 10 red for 1 black). The first player to obtain a red chip (when playing to 100) or a black chip (when playing to 1000) is the winner.

Variation: Use other numbers as rates of exchanges such as 2, 3, 5, 8, etc..

5. Provide students with appropriate activity sheets for reinforcing addition and subtraction skills presented in lesson.

Performance Assessment:

Children will be given three problems, one orally and two written, to assess how well the objectives of the lesson were met.

A. Oral:

Students will write two 3-digit numbers from clues given orally by the teacher and then find the sum. Example: In the first number, the ones' digit is 5. The tens' digit is l more than the ones' digit. The hundreds' digit is 2 more than the tens' digit. The second number has 4 ones. The tens' digit equals the number of boys in the class. The hundreds' digit is the number of feet a chicken has.

B. Written:

(1) Write a question that can be answered using the information in the story. Then find the answer.

Mary swam 567 meters at the indoor pool today. Yesterday she swam 498 meters.

(2) Write a story problem that you can solve using this number sentence: 459 + 64 = ?

Additional Activities:

1. Cooperative Problem Solving -- In groups of four, give each group an envelope with four papers in it. Each paper states the problem with a different clue on it. The group discusses the problem and the four clues. The first group that solves the problem and can explain how the solution was obtained wins. Example: Problem: How many seeds are in the sunflower? Clue 1: The number uses the digits 2, 7, and 8, not in that order. Clue 2: The 2 is not in the ones' place. Each digit is used once. Clue 3: The 7 is not in the hundreds' place. Clue 4: The 2 is not in the hundreds' place.

2. Rolling-the-Cube -- On a piece of paper, students make three short lines and directly below that three more short lines in preparation for adding two 3 digit numbers. A cube or die is rolled. The number appearing on the cube is put on one of the six blanks. The cube or die is rolled again and the second number is placed in one of the remaining blanks. The process is repeated until all six blanks are filled in. The two numbers are then added, and the student

with the largest sum is the winner.

3. Find-Hide-Show -- Give students a "Number Wheel Response Card" (Open Court Publishing Co.). State a number to make on their cards. After they find the number, they "hide" the card by their chest and when the teacher says "show", they hold up their card. Teachers can easily identify students having an understanding of place value and those needing additional help.

Extension:

To provide students with experiences in regrouping larger numbers, make a three dimensional mat called the "Daily Depositor" with places up to one million. Have the class predict whether they can accumulate one million dollars by the year's end if each day the class receives the number of $100 bills for the date of the month. For example, on the third of the month $300 is put into the Depositor and on the 27th of the month $2700 is added to the Depositor. The accumulation occurs throughout the years so there is experience with large numbers and regrouping (hundreds in the early months and thousands in the later months). Use play money from a game such as Life.

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Introduction To Equivalent Fractions

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Objective:

To examine the part-whole relationship of numbers and to compare one fraction to another in order to discover their equalities.

Materials Needed:

adding machine tape
crayons
paper
fraction puzzle pieces
masking tape

Strategies:

Each student will take a strip of adding machine tape that is 24 inches long. They will measure the crown of their head. Each tape will be labeled as halves, thirds, fourths, etc. These tapes will also be marked showing their fractional parts. Certain colors identify fractional parts--such as red marks 1/2, blue marks 1/3, orange marks 1/4, etc. After the measurements have been taken, each student will place his/her tape on the chalkboard with masking tape. From observation, students can clearly see that all of the red marks are aligned, as well as all of the other colored marks, that divide each strip into equal parts.

After the students have compared the strips and have noticed the relationships, they will begin a paper folding exercise that helps to develop the concept of how two fourths of the whole strip is equal to one half of the same strip. To do this, fold a sheet of paper in half then color that half sheet of paper. The students will open the paper to the full sheet and they can see that one half of the paper is colored. The students will continue to fold the paper into fourths, and as they unfold the paper, they can see that not only have they folded the paper into four equal parts, but that half of the paper is the same space shaded as the two out of four parts. The students will continue to fold the paper into eighths and sixteenths. They will continue using thirds, fifths, etc. The students will then use fraction puzzle pieces to create a square made of equal fraction pieces. Once a square has been completed, students can turn the puzzle pieces over to see the numeric value of each fraction and discover that the fractions that make up the square are equal to each other.

Performance Assessment:

Given twelve separate squares on a sheet of paper, the students will change regions that have been divided in half into regions of fourths, eighths and sixteenths. Regions that have been divided into thirds, will be changed into sixths and twelfths. As an added discussion, students will be able to see, looking at their original strips, how many students have the same or equal head band sizes.

Reference:

Reys, Robert E., M. Suydam, and M. Lindquist. **How Children Learn Mathematics** Prentice Hall, 1989.

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Fickled Fractions

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Objective: (Grades 4-8)

To review the ways in which fractions are made real in our world
To show the relationship of cross multiplication and equivalent fractions
To reinforce fraction skills

Materials Needed:

Measuring tape
Pencil
Crayons
Construction paper
Equivalent fraction strips
Ditto of a boy and girl doll

Recommended Strategy:

This lesson has been designed to enrich the students understanding of fractions after they have completed the study of fractions. Now we will attempt to show that fractions indeed have a place in the real world.
The students have learned to add, subtract, multiply, and divide fractions.
They also know how to:

- -change mixed numbers to improper fractions.
- -reduce fractions to lowest terms.
- -change fractions to a decimal; to a percent; to a ratio.
- -find the LCM and GCF.
- -solve or make equivalent fractions.

The students will have a discussion about why fractions are so important and why students find understanding fractions so difficult. How can we make fractions real to them? Following the discussion, the students will do various activities:

- -Label a doll that represents the students measurements. (students will add, subtract, multiply, divide, and reduce fractions using their body measurements.)
- -Use a calendar in order to do an activity that is a lead-in to cross multiplication and proportions.
- -Play an equivalent fraction game to reinforce problem solving techniques.

Performance Assessment:

Students will set up a proportion in order to solve word problems.

Multicultural Connections:

The proportion property was recognized by the early Hindus as an arithmetic rule. In the Seventh Century it was called the **rule of three** and was stated in words in the style of the times. Merchants regarded the rule highly and used it widely as a mechanical procedure without explanation. Prior to the Nineteenth Century the ability to use the rule of three was a mark of mathematical literacy. This explains cross multiplication and also how to find an unknown in solving proportions. Ex. a/b = c/d therefore aKd = bKc

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Addition and Subtraction of Signed Numbers

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Objective(s):

To master the addition and subtraction of signed numbers.
To recognize linear equations of the form x + a = b and their solutions.

Multicultural aspects:

Cities of the world including London, Peking, Moscow, Cairo, and Berlin are referred to in the Performance Assessment.

Materials needed:

For a class of 28: 3 paper lunchbags and 100 pennies

Strategy:

Ask the students to bring some pennies (no more than 10) with them to class the next day. Number the bags 1, 2 and 3 then place in each bag 18, 21 and 23 pennies respectively. In 3 groups (2 rows per group) have 1/2 the students place pennies into the group's bag and 1/2 take out pennies from their group's bag. (Make sure the amounts put in and taken out vary.) Have the students record the number of pennies they put in or took out.

Questions for the group to answer within the next 10 minutes: Are there more or less pennies in the bag? How many more or less? Next have each group count the number of pennies in their bag and answer the question. How many pennies were placed in the bag before class began?

Have a member from each group explain how they got their answers to the class while you point out that putting in pennies equals a **POSITIVE** number and taking out pennies equals a **NEGATIVE** number. Explain that they had to add or subtract positive and negative numbers to answer the questions. Also the number of pennies placed in the paper bag before class began served as the variable **X**, and they had to solve a simple linear equation to get the last answer.

The above activity leads to the following examples:

put in 8	and	put in 5	equals	put in 13
8	+	5	=	13
put in 7	and	take out 9	equals	take out 2
7	+	-9	=	-2
take out 4	and	take out 7	equals	take out 11
-4	+	-7	=	-11
take out 8	and	put in 11	equals	put in 3

-8	+	11	=	3

At this point a discussion of simplification of signs is needed.

5 = +5 the + sign is superfluous, so discard it.

- - = +, - - - = + - = -, - - - - = + + = +,

This may be visualized by using construction paper strips 1" by 6" as negative signs; join 2 negative signs together with a paper clip to make a positive sign.

For any addition or subtraction problem only one sign is necessary between each number in order to know what to do. +8 + - 7 -(-9) - +5 = 8 - 7 + 9 - 5

Now the class is ready to do problems in class and for homework in order to master the addition and subtraction of signed numbers.

Performance Assessment:

In the game of Civilization the population of a city must be content or happy in order to produce any goods. Given the facts that

A HAPPY PERSON	is worth	+7 points.
A CONTENT PERSON		0 points.
AN ANGRY PERSON		-4 points.
A HOSTILE PERSON		-10 points.

Given a city with 30 persons determine if the city is producing any goods. If the city is not producing, how many more happy persons does the city need to start producing? If producing, how many more angry or hostile persons will stop the city from producing?

Note: A city is represented by 30 circle faces on one sheet each drawn to show the 4 possible attitudes of its citizens.

Conclusions:

Positive and Negative Numbers are appropriate in any situation where opposites are present.

Evaluation:

A simple quiz with 9 nine-point problems with the above Performance Assessment for nineteen points.

Rubric:	19 points	Correct answer and notices and uses the multiplication of signed numbers.
	16 points	Correct answer presented clearly in complete sentences.
	13 points	Correct answer use of repeated addition and subtraction work shown neatly .
	10 points	Incorrect answer, correct method shown but error in addition or subtraction.

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5 points   Incorrect method or no method shown but correct answer
           without supporting arguments.
0 points   Incorrect answer - No answer - and invalid arguments.
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Working with Cuisenaire Rods In Mathematics

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Objective:

Fourth Grade students will learn the numerical value of each underlined letter of the standard Rod Code and develop systematic usage for building new units.

Materials Needed:

A set of Cuisenaire Rods for each student or groups of two
Construction Paper
Scissors
Transparencies
Overhead Projector

Strategy:

In order to effectively develop good skills for working with common denominators, students must first strengthen and reinforce their basic skills. These basic skills encompass such concepts as addition, subtraction, multiplication and division of whole numbers which form a foundation for fractions. The materials used reinforce concepts further by providing students with concrete examples of the skills that they practice.

Performance Assessment:

a. Given Cuisenaire Rods, introduced to strategies, and ample performance time, students will utilize the activity card, "Finding One."

b. The students will answer 5 out of 7 questions correctly while playing "Finding One."

c. The students will demonstrate whole fractions (reduced) using Cuisenaire Rods.

d. The students will demonstrate equivalent fractions using Cuisenaire Rods.

e. The students will discuss length, color, and shape of Cuisenaire Rods.

Multicultural Aspects:

Cuisenaire Rods were discovered in Thuin, Belgium over forty years ago by George Cuisenaire and are now recognized as a basic learning tool all over the world.

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The Generation Of Fractions

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Objectives:

To use a unique multiplication grid to help students realize that simple fractions (reduced fractions) may have many appearances, but have the same value.
To help students learn how to factor each denominator completely.

Materials needed:

Group of four students	Four 5 x 8 1/2 white tag boards
Ruler	Red construction paper for apples
Glue	Green construction paper for trees
Masking tape	Brown construction paper for tree trunks
Black marker	Make grids for multiplication tables

Strategy:

Students will select fractions written on cut out apples from a bag.
To begin use only even number fractions.
Example: The fraction 12/24 is selected by the students. Students look at the multiples of two column, and then count down to 12 grids in the multiples of two. The students stop on the sixth grid. Ask students to record where have counted. The students' final fraction should be 1/2. Remind the students that they must change multiples when the selected fractions can be further reduced.
The fraction 3/6 requires that they leave the multiples of two.
Students can visualize reduced terms and the final simple term. When odd fractions are selected students can compare how each fraction is divided by one and itself.

Performance Assessment:

Students write five higher term fractions for one simplified fraction.
Teacher observes and records results.
All higher terms and reduced fractions are hung on the tree.
Odd fractions are hung on a crab apple tree.

Multicultural Aspect:

Fractions were invented by the Ancient Egyptians.

Conclusions:

This activity may be used for small or large groups of students.

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A Method of Front-End Arithmetic

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Objectives:

Grades 3-l2

Upon completion of the Front-End Mathematics lesson, students will be able to:

a. Transfer computational fatigue from the most significant to the least significant columns.

b. Eliminate carry-overs and their errors.

c. Use one or more of the fundamental laws of commutation, association and distribution, and the concepts of place value and regrouping.

Multicultural Aspects:

Many peoples contributed to the development of the modern system of numerals. Any society that uses Arabic numerals can use the Front-End Method of Arithmetic for calculating.

Materials Needed:

Notebook Paper for a class of 20 students.
Pencils for the class.
Twenty store receipts from supermarkets.

Strategy:

Students will be given four shopping lists and asked to estimate the number of $20 bills needed to purchase the items on each list. Calculators are not allowed.

Students will be asked to add the figures on the list to obtain the exact totals.

Students will be taught the Front-End Method of Arithmetic.

Students will recalculate the shopping lists using front-end arithmetic without calculators.

Example of front-end addition:

```
$37.55
 63.86
 97.23
  8.98
```

```
l8
 25.
  2.4
   .22
l-7.62
l0
207.62
```

The numbers are lined up as usual in their proper vertical columns. The first column is totalled and the subtotal, 3+6+9=18, written in its proper place under the line. At this stage we already know that the final sum will exceed $l80. The second column is summed, its subtotal, 7+3+7+8=25, is written in its proper place under the line. The first two subtotals add up to $205, a second approximation to the final answer. The third column subtotal, 24, is again written in its proper place under the line. The first three subtotals give the partial sum $207.4, a third approximation to the final answer. The fourth column subtotal, 22, is again written in its proper place under the line. Added to the previous partial sum, it yields the final answer $207.62.

Performance Assessment:

Students will be given a post-test consisting of ten front-end addition problems using supermarket receipts. Students will be expected to use this new method to compute the problems with l00% accuracy.

Conclusions:

Front-end arithmetic provides an interesting variation for and supplement to, the classical rear-end approach. Students are able to add columns of figures without carrying. This method has real-world application to consumer mathematics.

Reference:

DeBethune, Andre J. **A Method of Front-End Arithmetic**, in Enrichment for the Grades, The National Council of Teachers of Mathematics, Inc. Washington, D.C., l963.

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Money: Demonstrating Coin Values up to $1.00

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Objective:

Students will use a variety of coins to make change up to the value of a dollar. (Lower Primary)

Materials:

large paper coins, coin paper money, real coins (100 pennies, 2 half dollars, 3 quarters, 5 dimes, 5 nickels per student), one sandwich bag for each student, 3x5 index cards on which are written coin values to be used (for example: show $0.25; show $0.25 use only one nickel; show $0.25 use no nickels), 81/2 x 11 boards on which are written the words "Put It Here".

Strategy:

1. Teacher attaches large paper coins to strips of paper and places the strips at various places along the floor. Teacher selects the sum of coins from one of the strips. Students find the strip whose coin value matches that sum.

2. Teacher places the above assortment of coins in the sandwich bags and distributes them such that each student has one bag.
   a. Students sort the coins by value.
   b. Students select one coin from each pile and arrange them in a column by size from largest to smallest.
   c. Students select another coin from each pile. Beside each coin use pennies to demonstrate the value of each coin.
   d. Students arrange second set of coins in a column by value from largest to smallest.
   e. Students compare and contrast both columns of coins.

3. Teacher reads cards. Students place that coin value on their desks.

4. Game (4 to 6 people): Caller reads cards. Players place coins equal to that value on the "Put It Here" board. The first player to place the correct amount on the board wins the point. The first player to accumulate 5 points wins the game and becomes the new caller.

Conclusion:

Use of these activities should familiarize students with individual coin values and assist them in learning to make change.

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"How Divine Is My Proportion?"

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Objectives (Staff):

Demonstrate a phenomenological approach to teaching mathematics.

Inspire others to use the approach.

Objectives (Grade 8):

Relate the ratio of successive numbers in the Fibonacci Sequence to the "divine proportion".

Compare approximate golden rectangles to human body proportions.

Materials:

Measure in advance and select items whose sides are in the approximate ratio of 1:1.6.

file cards (assorted sizes)	envelopes	charge plates	photos
greeting cards (assorted sizes)	invitations	pamphlets	books

Recommended Strategy:

Measure items and calculate the ratio of longest side divided by shortest side.

List quotients on the chalkboard and discuss similarities.

Measure the height and the distance from the top of the head to the middle finger tip with an arm extended to one side. Calculate the ratio of the two measurements.

Compare the ratio of body measurements to the results obtained from other items.

Determine a pattern and complete a number sequence:

1, 1, 2, 3, 5, 8, 13, 21, ...
(Additional numbers are optional.)

Calculate the ratio of two successive numbers:

1/1, 2/1, 3/2, 5/3, 8/5, 13/8, 21/13

(The ratio 21/13 equals 1.6154 rounded to the nearest ten-thousandth and represents the ratio of the sides of a golden rectangle.)

Compare the quotient of a golden rectangle ratio to ratios of selected items and body proportions.

Students should look for golden rectangles and divine proportion measurements at school, home and other places.

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Equivalent Fractions

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Objectives:

Given teacher guidance the fourth grade students will be able to:

1. Visualize and comprehend the relative values of fractions by making physical representations.
2. Use fractional parts of a "whole".
3. Recognize relative sizes and equivalent fractions.

Materials needed:

All materials listed are for an entire class.

- Ruler
- Pencil
- Scissors
- Strips of 3" x 18" construction paper
- Number cube (die) labeled with fractions

Strategy:

Take five strips of different color construction paper.
With your students, compare the strips to be sure they are all the same length.
Talk about the fact that the strips each represent "one whole" and the students will be cutting some into fractional parts.
Label one strip "one whole".
Take another strip and fold it carefully in half. Open it and count. Label each part 1/2 and cut on the fold line.
Take another strip and fold in half two times. Open and count the sections. Label each part 1/4 and then cut them apart.
Take another strip. Fold it in half three times. How many sections will there be this time? Open and count. Label each part 1/8 and cut them apart.
Continue with the last strip. Fold four times. This time the students will get 1/l6 for each section. Label each part 1/l6.
Students will measure and discuss using fractional parts of a whole.
Making a physical model of fractions provides reinforcement for understanding the relative values of fractions.

Follow Up Activity:

Divide the students into 4 to 6 groups. Start with one whole strip in front of each student. One student from each group will take a turn rolling the die. Take the strip which represents the fraction shown on the cube and place it on the whole strip. For example, if the fractional part 1/4 is rolled, place the 1/4 strip on the whole strip and continue rolling the die until the whole strip is covered. The first player to cover their whole strip wins.

Conclusion:

This is a good activity to help students in using fractional parts equivalent to a "whole" and aiding them in recognizing comparable sizes and equivalent fractions.

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Division For Third Graders

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Objective:

To use measurement to demonstrate division.

Materials needed:

a meter stick
a ball of cord
a pair of scissors

Strategy:

Seat the class in pairs. Have one student measure and the other cut.

1. Measure and cut a piece of cord 110 cm long.
2. Start at one end of the cord and cut pieces that are 8 cm long. Cut as many pieces as possible. Measure carefully.
3. Count the number of 8 cm pieces you have cut.
4. Measure the piece that is left over. It should measure 6 cm.

Repeat the process for other lengths of string.

Conclusion:

110 / 8 = 13 r6.

Evaluation:

For each division sentence, make and complete a table showing:

1. Length of single piece
2. Length of single pieces to be cut from single piece
3. Number of exact-size pieces that can be cut from single piece
4. Size of left-over piece (the remainder)
5. Division sentence (Give the division sentence this represents)

Repeat for the other examples.

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Prime and Composite Numbers

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Objective:

The main objective is to have a systematic method of deciding if a number is prime or not. This project is geared to fifth through ninth grades.

Materials Needed:

Large translucent container filled with water
Roll of masking tape
Pennies
Any permanent marker
Pencil
One or two vis-a-vis non-permanent markers
Three charts of numbers 1-100 on transparencies
A classroom set of the same chart on paper
A classroom set of an empty 10x10 grid
An overhead projector

Strategy:

The mini-teach is directed toward fifth through ninth grades. You give students the definitions of prime and composite numbers. You allow students systematically to go through the numbers crossing out or eliminating multiples of two, multiples of three, multiples of five, multiples of seven, etc. You continue until you reach the square root of the last number you are testing. When you are done, the remaining numbers are prime. Have students make a list of the numbers. For effect cut out the numbers from 1 to 100 from an acetate copy of a Sieve of Eratosthenes. Put them on the overhead projector. Take a pencil with a loop of masking tape and systematically remove the composite numbers. The remaining numbers are primes.

Take fifty to one hundred pieces of masking tape, each about one inch in size. Fold them in half so that the sticky side is together. In half of them, put a penny. With your permanent marker, write the prime numbers on the pieces of tape that have no pennies. Write the composite numbers on the pieces of tape that have pennies inside them. Throw these numbers into a container of water. The composite numbers will sink, and the prime numbers will float. You can have the number 1 off to the side.

Take an empty 10x10 grid. In row six column five, place the number 11. Then begin wrapping the numbers 12 through 110 around 11 in a clockwise fashion. You will find many primes on the right diagonal of the line of numbers.

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A Fictional History of Place Value

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Objective:

When presented with a two or three digit number the child will be able to rename it in several different ways including expanded form. The child will also be able to perform addition and subtraction of two and three digit numbers with the application of regrouping and the use of zero as a place holder.

Materials Needed:

Disks cut from construction paper with correct markings, done in marker, and backed with small flexible sticky backed magnets (necessary ONLY if your black board is magnetic). Small disks with markings can be used as hand outs so that the children can work in pairs after the initial explanation has been made. A sense of the ridiculous and the ability to present it with a straight face.

Strategy:

Once upon a time ... in the days when cave men huddled about their fires. It occurred that a piece of meat fell into the fire. By the time he was able to stab it out of the coals he had discovered cooked meat and shish-ka-bobs. As his enjoyment of cooked meat grew he realized that by keeping 'cave-cows' he was able to always have meat and demonstrate wealth by being able to provide that meat to his family when ever desired.

Each day the cows would be allowed out of the cave to graze. Each evening they would be herded back into the cave so that they were not stolen or attacked and killed.

A system of checking every cow as she entered or left was necessary to be sure that they all returned. A 'one-to-one' correspondence was developed and soon our brave rancher was counting his cows by matching one cow with one pebble. If, at the end of a day when the cows returned, there was an extra pebble the rancher knew that he was missing a cow. If there was a cow with no pebble to match, then he knew he had an extra cow.

Time has passed and we see our hero at the local cave bar with a pouch of small pebbles. He brags to his friends about how many 'cows' he has. As he opens his bag and shows a series of pebbles, each representing a single cow, there occurs the typical comparison of my "ugh" pebbles more than your "ughh" pebbles. Spoken numeral names have not yet been developed.

As evolution occurs we see that our cave man has tired of carrying about all those little pebbles. Because of his great powers of observation he would use that which he saw every day, his fingers, as a basis or **base** for his numbering. And soon a "group of fingers" of pebbles (we'll call it ten) became one stone.

> In our terms: one group of fingers or one stone
> and three extra pebbles became one group of the
> base and three extra or 1 ten and 3 extra = 13

But I modernize too quickly. While at the bar our young genius has found that it is not always convenient to carry that bag with him at all times. He must have a method of notation. His notation would be representative of his pebbles and stones.

```
     And so:  each finger  --->   a little pebble ---> o
              a group of fingers -->  a stone   --->   (*)
      Two stones  --->  (*) (*)    and a hand of pebbles --->  ooooo
      A cave cow had a cave calf ---> o  extra.


Now the addition problem:      (*) (*)    ooooo    2 groups of 10 and 5 extra
                           +       (*)       oo    1 group of  10 and 2 extra
                           (*) (*) (*)    ooooo    3 groups of 10 and 7 extra
                                             oo         (or) 37
```

```
Every time a "group of fingers" of stones appeared, it was traded in for a
larger rock or:  oooooor= (*)        And so we experience the first
                 oooooot                recorded history of carrying.

          (*) (*) (*)   ooooo
       +                 oooo                 39       3 tens and 9 extra
              (*) (*)    oooo               + 24       2 tens and 4 extra

   (*) (*) (*) (*) (*)   oooooor=(*)                   5 tens and 13 extra (or)
                         oooooot              63         6 tens and 3 extra
                           ooo
```

-- -

```
And the subtraction problem:  (*) (*) (*)      oo    3 groups of 10 and 2 extra
                        -             (*)   ooooo
                                               oo    1 group  of 10 and 7 extra
           Translates to:
                                   (*) (*)   ooooo
                                             ooooo
                                                oo   2 groups of 10 and 12 extra
                         -             (*)   ooooo
                                                oo   1 group  of 10 and 7 extra
                                       (*)   ooooo   1 group  of 10 and 5 extra
                                                          (or) 15

A one-to-one-correspondence for cancelling becomes obvious and so:
        (*) (*) (*) (*)   ooooo
                              o         46          4 tens and 6 extra
       -        (*) (*)   ooooo
                            ooo        -28          2 tens and 8 extra
         Translates to:                 18
            (*) (*) (*)   ooooo                     3 tens and 16 extra
                          ooooo
                          ooooo
                              o
      -         (*) (*)   ooooo                     2 tens and 8 extra
                            ooo
                    (*)   ooooo                     1 ten  and 8 extra
                            ooo                        (or)  18
```

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Fundamentals of Multiplication

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Objectives:

I will introduce third graders to the fundamentals of multiplication

(1) How multiplication is a quicker and neater form of addition

(2) How numbers in multiplication are placed into groups (or sets)

(3) How students within the classroom can simulate the concept of groups and (sets) to construct the visual effect of multiplication by way of forming groups of (2's) (3's) and (4's)

Materials:

cuisenaire blocks.

papers folded in half, thirds and forth

prop used to show an example of groups, pairs or sets

Teacher's Strategies:

Students will learn to add numbers and objects but the count will be equal in numbers and amounts

Students will learn with repeat addition that the larger your sum the longer and tedious your operation

Students will learn that addition is a slow type of multiplication
ex. 3 groups of 2's is 2+2+2=6

Students will reverse the order of 3 groups of 2's to 2 groups of 3 both operations will equal 6 as a product

Students will learn to put problems into simple word problems - ex. If 2 stamps cost 3 cents each how much will they cost? 2 groups of 3 is the same as 3+3=6. Six is your answer.

Classroom Projects:

Students will take 3 sheets of paper that have lines dividing it into halves, thirds and quarters. Horizontal lines interval of one inch from top to bottom.

Students will fold all 3 sheets along the fold lines.

Students will be given a problem 3 groups of 2's. The student will then take the paper folded in halves and then the student is to tear 3 groups of the horizontal lines so that they hold 3 strips the students will now count each fold which should equal 6.

Students will work cooperatively in groups of 3's.

Conclusion:

This program is design as an introduction of multiplication for third graders. I feel that the strips of papers can be another option for the teacher so that the class does not become to "cut an dry".

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Place Value

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Objectives:

The second grade students will:

1. Know the place value of the ones and the tens.
2. Know how many ones are in one ten.
3. Be able to write numbers using more than one place value.

Materials:

Cuisenaire rods, counting sticks, place value charts, and an overhead projector.

Strategies:

Tell the students to count the sticks as you hold up the sticks in front of the class. Once the ten sticks have been counted, put a rubber band around them. Have the students count four more sticks. Ask the students, "How many sticks am I holding?" "How many tens are there?" "How many ones?" Do several more examples using the counting sticks.

Present the cuisenaire rods to the students. Place on the overhead projector one orange rod and ten white rods. Tell the students that you want them to count the white rods as you place them on top of the orange rod. Ask the students, "How many white rods does it take to make one orange rod?" Then, say to the students, "We're going to call the orange rod the ten rod and the white rod the one rod." Draw on the board a place value chart. Then have a student come to the front of the class and place two orange rods and six white rods on the overhead projector. Ask, "How many rods are placed on the projector?" Once the answer is given, ask "How many ten's rods are there?" Write that answer in the ten's place on the place value chart. Next ask, "How many one's are there?" Write that answer in the one's place on the place value chart. Do several more examples.

Give each student a place value chart. Tell the students to place the correct number of rods on their chart in the correct position as you give them a number. Do several more examples using the cuisenaire rods.

For more practice give the students a worksheet concerned with the place value of the tens and the ones.

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Objectives

1) Students will learn that each part will be equal to its counterpart or parts.
2) Students will learn that all combined parts will equal one whole.
3) Students will learn that any shape can equally be divided into parts.
4) Students will learn to draw shapes and separate them into equal parts and write them in fractional form.

Equipment and Materials

Overhead Projector
Plastic Overlays and Transparencies
Pies, Knives, Apples, Cubes, Paper shapes shaded in 1/2's, 1/3's, and 1/4's
Plastic shapes

Recommended Strategy

1) Show the students models of shapes.
2) Have students name the shapes.
3) Have students cut the shapes into parts.
4) Have students switch around the parts.
5) Show the student that each part must be the same size, or equal to each other.
6) Use phrases like: is equal to, or the same as.

Evaluation

Have the student cut a pie in equal parts, and name the part they receive to eat.

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Fraction Message

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Objective

The student will be able to find pictorial representations of fractions and decode messages.

Equipment and Materials

Overhead projector	Transparencies	Typing paper
	Colored markers	Compass
	Cellophane tape	Protractor

Worksheet:

Prepare a worksheet using fractional statements that when solved, the student will get a letter (alphabet) which will be used in a code to solve the message. Example: "3 hrs. to a day"; "6 months to a year"; and "3 dimes to $.80." This information is placed in chart form with a space above each statement for a letter of the alphabet. When the statement is solved, the letter is filled in for that space. All the spaces are worked and filled in with the correct letter forming a code which will give a command for the student to carry out.

Transparencies:

Prepare transparencies which will show fractional parts of a circle. Color code each fractional part. A color can be used for all fractions showing thirds, fourths, and fifths. With typing paper, design the code by placing the letters (alphabets) in the lower corners and the fractional names in the upper right corner. Place the typing sheet behind the transparency and attach the top corners with tape.

Recommended Strategies

Review fractions by using the prepared transparencies. Remind the students that the numerator (number above the line) represents the sections used or shaded. The denominator (number below the line) represents the total number of equal parts of the circle. Discuss all transparencies and place them so that they can be viewed with the codes visible in a line. Distribute the worksheets in a pack or individually. Have the students solve each statement and identify the answer in the coded section near the top. The letter corresponding to the answer should be written above the statement. When finished, the student will read and act out the message. Allow time to decode and act out the message. Discuss any spelling errors. Make sure the entire class knows the correct answer before moving to the next message.

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IDENTIFICATION OF EQUIVALENT FRACTIONS
MODIFIED RUMMY - CARD GAME

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OBJECTIVES

1) The students will interpret the meaning of a fraction.
2) The students will identify the fractional representation for "one whole".
3) The students will recognize the renamed fraction after it has been increased or reduced.
4) The students will apply these skills in a "card game".

Materials

A deck of 52 fraction cards
3 x 5 index cards cut in half to form 3 x 2 1/2.
There are 13 sets of equivalent fractions.

2/4	3/6	4/8	8/16	1/5	2/10	3/15	4/20
2/6	3/9	4/12	6/18	5/8	10/16	15/24	20/32
4/6	6/9	8/12	10/15	1/9	2/18	3/27	4/36
1/4	2/8	3/12	4/16	2/5	4/10	6/15	8/20
3/4	6/8	9/12	12/16	3/8	6/16	9/24	12/32
1/8	2/16	3/24	4/32	3/5	6/10	9/15	12/20
			1/6	2/12	3/18	4/24	

Cards should be labeled in alternating corners.

```
 ____________
|6/10        |
|            |
|            |
|            |
|            |
|            |
|            |
|            |
|            |
|            |
|_______ 0l/9|
```

METHOD OF PLAY

Two to four players. Cards are dealt one at a time in a clockwise manner such that each player gets seven cards. The deck is placed in the center and a single card is turned up as a waste pile. Play continues around the group as in traditional rummy (taking a card and making a discard.) The object is to get a group of either three or four cards that have the same equivalent and three or four cards with the same denominator.

```
  ________
 |1/4  ___|____
 |    |2/8  ___|_____
 |    |    |3/12  ___|____
 |    |    |      |4/16 ___|____
 |    |    |      |    |1/9  ___|____
 |    |    |      |    |    |3/9 ____|____
 |____|    |      |    |    |    |6/9      |
      |____|      |    |    |    |         |
           |_____|     |    |    |         |
                  |____|    |    |         |
                       |____|    |         |
                            |____|         |
                                 |_____9/6|
```

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Introducing Powers and Models.I

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Objectives:

(Adaptable to grades 4-10)
-To discover how to square numbers; that squares are areas; the meaning of terms: Exponent, to the power of, etc.
-To visualize "to the powers of" 2, and 3, using a plane grid and a series of models of geometric shapes, of plane figures, then of solids; to see the relationships and certain properties of various geometric figures.
-To construct models after handling a series of models, and drawing them, to be able to describe squares, rectangles, cubes, triangles, triangular pyramids, tetrahedrons, hexagons, prisms, dodecagons, et al.
-To enjoy manipulating puzzle pieces to form some of the above shapes and figures by the correct assembly of pre-cut parts, to develop and reinforce concepts absorbed, as well as visualization and creativity in spatial relations.

Apparatus Needed: (Materials for chalkboard need to be adapted.)

Overhead Projector, acetate sheet with square centimeter grid pre-drawn on it, colored marker pens, clear plastic protractor, several pre-cut clear or translucent squares, rectangles, right triangles, (at least two with the same side measurements as the square and cube to be overlaid on the acetate sheet grid, and pairs of right triangles with differing sides which can be matched to form squares or rectangles when their right angles are placed in opposition), equilateral and isosceles triangles with which to form trapezoids, rhombi, parallelograms, hexagons, etc. and three dimensional figures, e.g. cubes, pyramids, tetrahedrons, etc.

Scissors, tape, and grid (graph paper or same unit grid sheets used on the overhead) to distribute to students, with and without patterns for models to be cut and assembled.

(Optional: Precut enough small right triangles to give each student one to keep.)

Game pieces and pre-cut puzzle sets, e.g., the Pythagorean rectangle, the square within a square, the dodecagon.

Recommended Strategy

Factoring Squares: to illustrate the power of 2 and that squares are areas.

On the overhead projector lay out a grid sheet. Number across the top and down the left side (x and y axis) to the same ending number. Beginning with square 1, ask students for the products of each number on the x axis across the top multiplied by its match down the y axis. Fill in the intersecting squares, or if pre-done, expose each using a cover sheet until the entire series of squares is complete. Outline the right and bottom perpendicular boundaries of each square thus produced with bright markers. Have students count at least the first few squares enclosed by each, to verify and visualize the meaning of area, (factors multiplied or squared).

As the diagonal bisecting each square develops down the grid, produced by filling in the products, ask students to identify it: the hypotenuse of the right triangles simultaneously produced.

Elicit observations of students about the intervals between the products of the factors squared. (Odd numbers; at higher grade levels, possible algebraic formulae to be derived, ...$y = mx + b$...). Write all valid statements on chalkboard, in addition to the "square facts," and terms illustrated, e.g. $3 \times 3 = 9, = 3^2$.

Collect the grids in sets of four and arrange them into the Cartesian Quadrants to display on a bulletin or window.

Models of precut squares can be positioned on the grid sheet on the overhead. Overlay right triangles bisecting the square diagonally. Derive the relationships of their angles and sides and their respective areas. Overlay examples of congruities and similarities. Move along in the same way with the cube model made by assembling six of the same squares used to start. Relate and show the other figures and shapes listed above, and others as desired. Follow this by identifying then distributing the models among the students to manipulate, draw, and tell/write observations about, as well as name. Be sure to reinforce by writing names, terms, observations on the chalkboard, and by repeated questions. Ask students to explain, demonstrate, show their model-making, and to assemble the puzzle parts named above.

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Math Technique in Multiplication and Division of Fractions

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Instructional Objectives:

1. To multiply fractions by whole numbers and fractions.
2. To divide fractions by whole numbers and fractions.

Review Objective:

To review unit concepts and skills.

Apparatus Needed:

2-Poster Boards (size 22" x 28") divided in three parts: center square (8"x 8"); second section (9" x 7 1/2") from center point of the poster; third section (out side spaces) (5 x 3 1/2") from second section. Center square is used for placing different numbers as the whole number or mixed fractions. The second sections are used for fractions. The third sections (outside spaces) are used for one or two answers. Black marker, ruler, magnetic tape and nine (9) squares (8"x8") with numbers from 2, 3, etc. The fractions were placed in the second section with a black marker before laminating, which was done at the Bd. of Ed., 3th floor west.

Recommended Strategy:

This mini teach is directed toward learning disabled students, but this is a problem common to all students. To understand the basic concepts of fractions, demonstrate step-by-step procedures to be used in this lesson. Teacher will use center square of the posterboard, placing a whole number in the center. Fractions are on the second section of posterboard and the third section of the posterboard will be used to compute student answers. Example 8 x 3/4 = 6; 8 x 1/6 = 1 1/3. Posterboards will be attached to blackboard with magnetic tape. These steps (multiplication or division) may be repeated more than once, because there are eight fractions on each board and a different whole number can be used as often as needed. Students will note that their answers can be found simply by multiplying whole number by numerator, then divide by the denominator to get the product. Teacher will introduce concept of dividing fractions with second posterboard in the same method, step-by step procedures in dividing fractions. Give the numerators and denominators colors, like red for numerators and green for the denominators. Students can see the interchanging of numerator and denominator, which is called the reciprocal of the fraction. Example, the reciprocal of 3/4 is 4/3. Have the students complete the exercises, this can be used to provide stimulation and practice.

This step may be repeated more than once, because there are eight fractions on each board and use a different whole number, if you so desire. Have the student to note that answers could be found simply by multiplying whole number by numerator, then dividing by the denominator to get the product.

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Introduction to Fractions on the Numberline

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Objectives

Students often have trouble (for any number of reasons) reading fractional parts of an inch on a ruler. They also have difficulty dealing meaningfully with the typical numberline because it does not readily lend itself to the students being able to recognize fractional parts or mixed numbers in correct ordering or sequencing. Using color-cued fraction strips in conjunction with color-cued numberlines and color-cued denominators, along with other manipulatives, the students will be able to use the numberline to:

1. Correctly order and sequence fractions;
2. Compare, add, and subtract fractions;
3. Change mixed numbers to improper fractions;
4. Change improper fractions to mixed numbers;
5. Find a fractional number between any two fractional numbers.

Apparatus Needed

Color-cued fraction strips (whole, halves, fourths). Numberlines, color-cued (four different sizes), with color-cued denominators. Above items drawn on white posterboard and laminated. Magnetic tape, transparency sheets(4), rulers, overhead projector, projector pens, markers and worksheets.

Recommended Strategy

The teacher will discuss some of the difficulties students are having when working with fractions, such as: their inability to write or name the points correctly on a typical numberline (here teacher shows the drawing of a typical numberline). The teacher will also display an example of positive and negative rational numbers being used on the numberline, using the overhead projector. Students will be given color-cued fraction strips to develop basic fraction concepts and correct sequencing. Once they are familiar with the use of the fraction strips, they will work with those fraction strips on the numberline, which will also be color-cued for an easier transition. For this lesson we will use only four segments of fraction strips on the numberline (wholes, halves, and fourths). Students will review the following terms: fraction, improper fractions, equivalent fractions, and mixed numbers. A worksheet will be given on the use of equivalent fractions to reinforce learning.

The students will practice again with the color-cued fraction strips to further develop basic fraction concepts and correct sequencing. Also, they will use the color-cued fraction strips above the numberline which will provide immediate reference to the concrete and because of the visual cueing, they will be able to proceed comfortably with other work on the numberline.

With concrete examples and demonstrations by the teacher of how the numberline can be used to find an infinite number of fractional numbers, shown on the overhead projector, the students will be able to:

1. Write a coordinate for each dot on a given numberline;
2 Correctly order and sequence fractions on the numberline;
3. Express improper fractions as mixed numbers;
4. Change a mixed number to an improper fraction;
5. Find fractional numbers between any two fractional numbers where

$$\frac{a + b}{2}$$

Students will be given worksheets that parallel, step-by-step, what is being demonstrated by the teacher on the overhead projector and the blackboard.

Use of the color-cued fraction strips and color-cued numberline will help those students who are having problems find answers to some of their more difficult problems when using fractions on the number line.

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Equivalent Fractions

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Objective:

Students will be able to recognize fractions of equal value and that name the same amount (number).

Materials:

Paper strips, circles, scissors, paper

Recommended Strategy

Have students fold strips to show halves, fourths, and eighths. Next have students cut circles to show thirds, sixths, and ninths. Students will then tell fractions that name the same amount by taking the fraction strips and measuring. Teacher will ask questions like, "How many of the parts on a fourths strip are the same or equal to one half"? Have students work in small groups to find equivalent fractions given by the teacher. Students will take circles, cut sections and match equivalent fractions.

Give students worksheets with strips and let students shade areas to show equivalent fractions. To reinforce fractions, let students play Fraction Bingo. Fraction Bingo is played by giving each student a game card. A game card has ten squares and each square has a fraction. A student may cover a square when the fraction in that square is called or an equivalent fraction is called. The regular rules of bingo apply thereafter. Another game that can be used is Fraction Rummy. Teacher will prepare 40 cards (index cards are very useful) by writing either a fraction or an equivalent fraction picture on each card. Each of two to four players is given seven cards; the rest are placed in a stack faced down. Turn one card face up. A player may take the card that is face up or a card from the stack. Every time a card is matched, a player may lay the pair down. The object is for one player to play all of his or her cards.

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Introducing Powers And Models.II

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Objectives:

Additional Activity: Multiplication Rummy

A card game to practice rapid calculation and increase the acuity of excellent students.

Encourages initiatives to create variations of this game, as long as rules are fair and consistent.

Apparatus (Materials) Needed

A pack of index cards (both sides blank are best), cut in half, i.e. 2 1/2 x 3 inches, markers to number the cards.

Recommended Strategy

Choose the times table products and factors to be practiced, and mark each number on one card. Include at least 50 in total, for 2 to 5 players, double all numbers for a double deck for 6 to 8 players, the maximum to play together. Have students make more decks for more groups. Operation cards may be included for a game in which more than one operation can be used.

Deal one card at a time, until all players have five each. The top card of the center pile is turned up next to it.

The first player left of the dealer begins by taking a card, either the one turned up already or the top of the center pile. He looks for a true statement to lay out on the board, (the table) from the cards he holds, e.g. 7, 8, 56. If he has a true combination, he calls out the equation while laying down cards for all to see and agree. He then puts these in his personal "book" (or pile), to be totaled at the end. One card is discarded, placed on top of the turned up one next to the center pile, at each turn. If a player makes no statement, he is still to pick the top card, and discard with each turn. Play continues until either the center deck is finished, or one player has used all his cards to lay out statements. Winner may be the one to go out first, or the one with the highest total by adding his personal book, pack.

Individual students may be assigned (rewarded) the task of designing the backs of a game deck.

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Understanding Fractions

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Objective:

Students will be able to recognize and understand equal fractions in relationship to a whole unit.

Materials Needed:

Construction Paper (cut into strips of equal widths and lengths)
Paper clips
Pen (preferably black)
Cookbooks (for recipes)
Patterns (for sewing)
Scissors
Various fruits (cut into fractional parts, which may be shared with the students at the end of this activity)

Recommended Strategy:

Discuss with the students the fact that fractions are a part of their daily lives. Elicit from the students some of these areas. The students should tell you of such fractions as related to cooking, sewing, money, food, etc. Have samples of foods, vegetables, patterns, cookbooks, etc. divided into fractional parts. Give the students an opportunity to touch and discuss these items. Depending on the level of the students, you may want to stop the lesson at this point until another day. If you are going to continue, proceed in the following manner.

Using assorted sheets of construction paper, cut each sheet into strips of equal widths and lengths. Your first strip will represent a whole unit. With a paper clip, make a bundle of strips of various colors for each student. Have the students lay the first strip out on their desk. The first strip will remain a whole unit. Tell the students this strip will represent a whole unit. The second strip will be folded into two equal parts (one-half, 1/2). At this point, have the students compare 1/2 strip with the whole strip. How many halves make a whole? Elicit from the students the correct response and discussion of the meaning of one half. The next strip should be folded into three equal parts (one-third, 1/3). Be sure to give the students an opportunity to experiment with the folding. Some of them may need help. Have the students compare 1/3 strip to the whole strip. How many thirds make a whole unit? Give the students an opportunity to compare and discuss. Have the students compare 1/2 and 1/3 strips. Which is the largest, 1/2 or 1/3? Be sure to allow the students time to compare and discuss. As you allow the students to fold each strip, be sure to have them draw lines to show the divisions of each part of the strip. The students should also be allowed to write the fractional names on each part. Proceed in this manner until you have reached 1/6. At this point you should stop with the folding. If there is enough time let the students compare the fractional parts they have made and see if they can make other fractional parts(i.e. fold 1/2 in half to get 1/4, fold the 1/4 in half to get 1/8, fold the 1/5 in half to get 1/10, etc). This lesson can be continued for several days depending upon the level of your class. You may use this folding activity to show other mathematical operations.

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Odometers and the Place Value Chart

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Objectives:
To add decimals with the use of the odometer; To place given numbers on the place value chart; To add numbers to the millionths on the calculator.

Apparatus needed:
Place value chart, calculators, overhead projector, projection calculator, lightweight cardboard, cutting instrument (scissors and single-edge razor blades), masking tape or scotch tape, pencils, straight edge and markers.

Strategies:
Students will begin to make odometers by cutting five rectangular shaped holes out of a piece of lightweight cardboard. Another long strip of card board can be taped to the back at each end of the strip. Now students are to make narrow strips (one strip for each hole cut) with the digits 0 through 9 written on them, spaced at even intervals. These are then looped behind the cardboard strip on the large card. The digits should then be able to show through the windows. Students can locate the decimal point to show tenths, then label the "odometer" to indicate kilometers.

To add 58.2 km and 63.9 km, one first registers 58.2 on the odometer, then turns the tenths loop nine units. When a zero is reached in the tenths window, the ones are increased by 1 just as an odometer in a car would function. The student works successively from right to left, increasing the ones column by 3, and tens column by 6, remembering that when a zero is reached in a column it should trigger an increase in the column to the left. Students should practice several problems using the odometer.

Activities
For this activity you will need a place value chart. The chart could be purchased or you could make one yourself. If you decide to make the chart it can be extended to include as many decimal places as you need. You will have many examples of number like sixty-seven and four thousand two hundred fifty-one millionth, seventy and one hundred twenty-twenty-three thousandths. Each number will be written on a card and the students should be able to place them correctly on the place value chart.

Another activity that could be used is working with the projection calculator. Students should use their calculators to add decimals.
Example 258.009878 + 009.787 + 89.1949 +.78
You will do the same problem using the projection calculator and the overhead projector.

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Basic Mathematical Operations Using Mathtiles

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Objectives:

Using a concrete model, MATHTILES--

1. The students will be able to do addition-
2. The students will be able to do subtraction-
3. The students will be able to do division-
4. The students will be able to do multiplication-

of whole numbers, which will enable them to develop better math skills with the use of these manipulative materials.

Apparatus Needed:

Six (6) sizes of MATHTILES, which includes the following sizes -- Unit tiles or 1-tile (1x1); 5-tile (1x5); 10-tile (1x10); 25-tile (5x5); 50-tile (5x10); 100-tile (10x10). One display board, MATHTILES Manual, Overhead projector, magnetic tape, posterboard, transparency sheets, pen to use with the overhead projector, and Labsheets for addition, subtraction, multiplication and division.

The six sizes of Arithmetic Tiles used as visual aids in my Mini-Teach were cut out of plexiglass in the lab. The posterboard was laminated at 1819 W. Pershing and then I used a scale of 1/2 inch to an inch to cut out the manipulatives that were used by the class to do the mathematical operations on the labsheets.

Recommended Strategy:

The class will begin with an explanation by the teacher of the kinds, values and uses for the MATHTILES in the classroom. Students will learn that MATHTILES are manipulative learning materials designed to be used in Arithmetic and Algebra and that they can be used at many levels, second grade through high school.

There are two kinds of tiles: the Arithmetic Tiles which consist of all the rectangles which can be built with sides measuring either 1, 5, or 10; and the Algebra Tiles which includes all the rectangles whose sides are either 1 or X, where X is not a whole multiple of 1. The Algebra Tiles will not be used in this lesson since we are doing the basic mathematical operations of addition, subtraction, multiplication and division.

The six sizes of Arithmetic Tiles in the set are used to represent whole numbers. The value of an Arithmetic Tile is the number of unit tiles needed to cover it. For example: The 1-tile or unit is (1x1); 5-tile is (1x5); 10-tile is (1x10); 25-tile is (5x5); 50-tile is (5x10); 100-tile is (10x10). At this point, the teacher will display the different sizes of tiles on the blackboard and also pass out a sheet showing the tiles and the value of each.

Discussion will continue and the teacher will describe the different things that you can do with MATHTILES, such as: Finding the value of groups of Arithmetic Tiles; Predetermining values; Trading groups of tiles to solve problems; Computing addition, subtraction, division, and multiplication.

The teacher, with students helping, will do samples of each of MATHTILES basic operations on the overhead projector; also an explanation will be given at each stage of the operations on the procedure to follow while working with the MATHTILES. For example: when trading tiles, students will be made aware of the restrictions that permit trading only between groups of tiles that have the same value. You can trade a 5-unit tile with a 5-tile when needed, just as you exchange 5 pennies for a nickel.

Procedures:

ADDITION--when adding, represent each number to be added by a group of tiles. Then combine these groups into one group. The combined groups of tiles then represents the sum.

SUBTRACTION--when subtracting, only set out tiles to represent the first number in the problem. Then take away tiles representing the second number. The group of tiles remaining is the answer.

DIVISION--when dividing, display the product on the surface of the display board and the known factor along the vertical edge of the board. Then use the tiles on the board's surface to build a rectangle having one dimension as indicated by the tiles along the edge. Then we place additional tiles along the horizontal edge of the board to measure the rectangle's second dimension. This length is our missing factor. Division problems are computed using the MATHTILES Board.

MULTIPLICATION--multiplication problems are done on the MATHTILES Display Board. The two numbers to be multiplied are shown by placing tiles in the grooves along the left and bottom sides of the board. Then a rectangle with these dimensions is built on the flat surface of the board using additional tiles. The area of this rectangle is the product of the two numbers to be multiplied.

Throughout the lesson and at each step, students will be given Labsheets to do the computations for practice. Students will work at their own pace since it is not necessary that every problem on the Labsheets be done.

Complete Classroom Sets with 180 reproducible labsheets is available from--Key Curriculum Press
1150 65th Street
Emeryville CA 94608
(888) 877-7240

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Adding Integers

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Objectives:

1. The students will be able to add integers.
2. The students will be able to subtract integers.
3. The students will be able to define:
    - A. Additive inverse
    - B. Identity element of addition
    - C. Associative property of addition
    - D. Addend
    - E. Sum
    - F. Magnitude
4. The student will be able to follow oral directions.
5. The student will be able to add and subtract integers without using the adding machine.
6. The students will be able to write a definition for adding integers and one for subtracting integers.

Apparatus Needed:

1. Poster board. (11" x 14")
2. Cut strips of paper from the poster board of a pre-determined length and width.
3. A ruler or a straightedge.
4. Pencils.
5. Felt tip pens to write the numerals on the adding machine.

Recommended Strategy:

I will tell each class that we are going to make an adding machine. We will make a machine out of paper. This machine will add certain combinations of integers. (Note: The extent of the combinations depends on the length of the scales on the "Addend" number lines.) Let's get the show on the road. I will give each student a strip of paper and a ruler. The paper has three lines on one side. Turn that side face up. We are going to divide each line into two equal parts. (Note: Give oral instructions as well as visual instructions for dividing the line into two equal parts.) Ask the students to put a tick mark," - ", at the midpoint of each line. Tell students to put a zero besides each tick mark on the lines. (Note: Turn rulers to the metric side.) Put a tick mark one cm (centimeter) apart on the line in the middle. Put a tick mark two cm apart for each of the other two lines. (Note: Check the students' papers for accuracy.) We are ready to write the numerals on the **adding machine**. Count upward using positive integers for each tick mark. Count downward using negative integers for each tick mark. (Note: Check papers for errors.)

Now, let's label the lines. Write the word, "SUM," over the line in the middle. Write the word, "ADDEND," over each of the other two lines. You have just made an **adding machine**.

Write "ADDEND + ADDEND = SUM" on the board or overhead projector to explain adding two integers. Write any combination similar to the one below.

+6 + (+4) = +10
+6 + (-4) = +2
-6 + (+4) = -2
-6 + (-4) = -10

Ask the students to connect the "ADDENDS" with their ruler or straightedge to verify the answers. (Note: If the same combinations are used, the students will, hopefully, intuitively determine a definition for adding or subtracting integers.)

Write "SUM - ADDEND = ADDEND" on the board to explain subtraction. Write several combinations similar to the one below.

+8 - (+5) = +3
+8 - (-5) = +13
-8 - (+5) = -13
-8 - (-5) = -3

The students can verify the answers by connecting the "SUM" and the "ADDEND" with a straightedge.

This approach has worked for me in the past.

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Locating Rational Numbers On the Number Line

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Objective:

1: The learner will use the name RATIONAL NUMBER when referring to locations on the number line.
2: The learner will write rational numbers as the ratio of two integers.
3: The learner will convert each rational number to a mixed number.
4: The learner will divide any given length into n equal parts.

Apparatus Needed:
Number line, straight edge, compass, pencil, paper.

Recommended Strategy:
Once the student is comfortable with the concept that integers, positive and negative, can be located on the number line, proceed to identifying all rational numbers as a ratio of two integers. If the rational number is an improper fraction, convert it into a mixed number. It will then become obvious between which two integers is this rational number. For fractional parts of the next integer, such as divisions of 5ths or 7ths, for example, the problem is how to divide the line segment into n equal parts. This lesson is about how to locate the rational number on the number line which is a fractional part of the next integer.

1. Teach the student that to divide any given length into n equal parts write the fractional part in the form a/b where a and b are positive integers (a rational number).

2. Change improper fractions to mixed numbers so that a/b = k+(m/n) where k is a positive number and the fraction m/n is converted to lowest terms.

3. Divide the line segment between k and the k+1 position into n equal parts, which can always be done by straight edge and compass construction, by marking off n equal parts on a **y-axis** and marking off the length of the line segment on the **x-axis**. The two axis do not even have to be at right angles to each other. Connect the last nth position with a straight line to the end of the line segment on the **x-axis** and proceed to construct n similar triangles. You will see that the line segment is now divided into n equal parts.

4 .Physically place this divided line segment on k and k+1 of the number line and count off m divisions. This is the location of the

a/b rational number.

5. For negative rational numbers teach the same strategy and instruct the student that this rational number is on the left side of the zero number.

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CONTINUED FRACTIONS WITH A CALCULATOR

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Objectives:
To learn how to evaluate Continued Fractions by taking many reciprocals with a calculator.

Materials:
Paper, pencil and a hand calculator--preferable a freebie-from-the-bank-four-banger type.

Strategies:
Use the definition of a Continued Fraction to generate various examples. Try to predict the value of the current fraction in the light of previous work. Keep it very experimental. Should interest wane, give several examples of rational numbers expressed as Continued Fractions. Should even this become boring, give the expression for tan z as a Continued Fraction and try it out for several values of z in radian measure. (I doubt that either of these alternatives will be necessary in a single class of 40 minutes.)

A FEW NOTES:
I initially encountered Continued Fractions (henceforth C.F.) as problems from the contests that our Lane-Tech-math teams enter. I began to play around with them just to see what would happen. They are fun this way.**This is the phenomenological way I want to present them in this mini-teach.**
This mini-teach on C.F. has driven me to the library for a look at several math dictionaries. Most of the 7 or 8 that I found discuss Continued Fractions. Some tell you more than you would ever want to know.
Barnes and Noble's **Dictionary of Mathematics**--1972, Millington and Millinton--defines a continued fraction as "an integer and a fraction, the denominator of which is also an integer and a fraction, etc." **This definition is the springboard for my lesson.**
Simon and Schuster's **The Universal Encyclopedia of Mathematics**--1969--states that:"Every rational number a/b (a, b positive integers) can be developed as a continued fraction." This idea is beyond the original scope of my mini-teach, but if I get stuck I shall try several examples. Recall my strategies above.
Also from the above source I found these lines: "Irrational numbers can be developed as infinite continued fractions. Conversely every infinite continued fraction in an irrational number." I shall not get to these ideas in this introductory mini-teach, but they could be dealt with in a future class, should sufficient interest arise.
In MIT Press's **Encyclopedic Dictionary of Mathematics**, written by the Mathematics Society of Japan, I found an expansion of tan z as a continued fraction with powers of z in the denominators. A trig-conscious class could try several values of z (in radians) just to see if it works.

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Mathematics/Physics

Collecting Data and Graphing

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Objectives:

This is a multi-level lesson:

- To count the number of different colored cubes.
- To work in pairs cooperatively.
- To construct a graph using various data and where to plot it.
- To see the relationship of student's arm span versus height.
- To learn to use the meter stick.
- To compare data with their friends.

Materials:

2 cm. sq. interlocking cubes, graph sheets, crayons, rulers, and meter sticks.

Strategy:

- To count the colored cubes and see who has more or less of each color (Comparing).
- To sort or group the cubes by colors.
- To graph your results onto the graph paper.
- To work in pairs to measure arm span and height.
- To record your results in centimeters and inches.
- To compare your results with the rest of the class.

Performance Assessment:

To check the student's understanding of this experience with measuring arm span versus height, let the students measure each other with the meter stick. Graph another classroom with the same age as your class, to compare data. Draw conclusions can be learned form both experiments.

Conclusions:

The students will be able to become familiar with these two experiments. Also, they will learn to graph using the data they have collected and how to use a meter stick.

Chandra E. Price - Burnham Inclusive Academy

Environmental Graphing/Eco Graphs

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Objective(s):

Grade levels 2nd through 4th
Duration: 1 week

Students will be able to:
1. define what a graph is
2. use vocabulary words associated with graphs
3. note how graphing is a part of our everyday lives

Materials Needed:

List vocabulary words associated with graphing ---hypothesis, control, graph, prediction, set, relationships greater than (<), less than (>), equal (=), percent and symbol (%), average, data, compare, centimeter grid, fractions, grid, balance, mass, paper, pencil chalk, raisin bread, M & M, crayons, birthday hots, graph paper, magnifying glasses, paper clips, scissors, masking tape and dittos.

Strategy:

Activity-1 Bar/Human Graph...Students will be introduced to bar and human graphs by way of an individual and group activity. They will work in groups of three and circulate around the room and report back to the group how many people were born in what month of the year. They will use data tables with the months of the year and a place to record students names. Next, the students will make birthday hats (Note: create their own hat), and make a human graph. Finally, they will go back and record their data on their data sheets. (Note: Data will be recorded on a teacher made graph chart which can be displayed either on the blackboard, overhead or floor).

Activity-2 HOW MANY RAISINS ARE IN RAISIN BREAD?....Students will be introduced to the term estimation. Using everyday items, such as raisin bread they will estimate and use the actual results of their findings. This will also allow them to sort, compare, record and eat their results.

Activity-3 YOU GOT THE BLUES?.....Students will get added reinforcement of the term estimation by using M & M's or Skittles to see if one color of the candy is more prevalent than another. This will be done when students are given individual bags of M & M's or Skittles to actually see for themselves. They must sort, compare and count colors. Then, they will group the colors, note how many of each color their are and record their findings. (Note: Depending on the age level students will solve problems of greater or less than, and /or percent.) They will again see how graphing relates to our lives.

Activity-4 Spinning Ghosts?????? The students will be able to hypothesize which Ghost will spin. Students will obtain four paper clips and five ghost patterns. They will number (1-5) and cut out the patterns, and place one of the paper clips on different locations of 4 of 5 ghosts. The remaining ghost that doesn't have a paper clip will be the control. The questions for the students will be what causes the ghost to spin? (Note: Students need to diagram each ghost and location of the paper clip on a separate sheet of paper). Using their numbered GHOSTS they are to place their findings on a wall chart.

Performance Assessment:

1. oral assessment of each activity. (informally)
2. written evaluation of objectives and key concepts.
   (multiple choice and essay)
3. Tape recording of lesson.
4. Video of lesson

Conclusions:

With 80% accuracy, the students will be able to explain orally how graphs affect our every day life.

References:

Aims Educational Foundation, September 1991.

Aims Educational Foundation, October 1986.

Math and Graphs. Donna Kay Buck and Frances Hildebrand. Critical Thinking Day Software. 1995.

Aims Fall into Math. Midwest Publication, 1996.

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Frana Allen - SKinner School

The Ups and Downs of Graphing

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Objective(s):

The students (grades 4 through 8) will be able to: distinguish between qualitative and quantitative experiments, define manipulated, responding and controlled variables, graphing, horizontal and manipulating axis, extrapolation and interpolation.

Materials Needed:

Individual Activity: graph paper, colored pencils, pencil and paper, a transparent ruler

Strategy:

For the teacher: (Teacher's language is important don't let it hang YOU up....Have fun with this, MY KIDS DID!) Teachers.....This is an introduction to the quantitative approach to science that I feel is easy to learn. I remind the students through visual aides the difference between quantitative and qualitative approach to science graphing. Note: It is imperative that the students are ready to graduate from bar graphs to point graphs. I explain to the students that the point graph replaces the bar with a dot or point at the center of the top of the bar. Using the chalkboard, I have the students write the definitions of the terms they will use in doing the experiment. Graphing is fun.....but, there are certain facts one must keep in mind when doing graphing...I remind the students that all the data points are not going to fit perfectly; however, we must really try to fit them perfectly. We must fit a straight line through the area of the data points. It should be noted that if they do obtain data points that do not fit a straight line, it is due to the problems in obtaining the data, unsteady hand, and or a poor read. To assure a good fit, also, known as the best fit line, remind the students that they should make as many points on the graph as possible.(At least 3). When students look at the data points on a graph to draw a conclusion it is called, interpolation. Sometimes experiments require students to make a prediction beyond the last data the last data point this is called extrapolation.

It is important that the students know that in this experiment they will be counting in centimeters (cm).

Part 2

BOUNCING BALL EXPERIMENT

Materials:
Cooperative Groups of 3---2 meter sticks, 1 tennis ball, 1 super ball, strip

of masking tape, 1 additional sheet of graph paper. Note: This is one group set up.

Procedure:
1. Remember each students should have a job
   Recorder, materials gatherer, director, experimentor, etc.
2. Go over the vocabulary used in the experiment
3. Go over the expectations you want each student and group of students to do
4. Read the procedure with the students
5. If you find it necessary, demonstrate the set up

Performance Assessment:

Bouncing Balls Data Sheet
Label drawing of experiment. Note: H1 is the release height and H2 the bounce height. Label H1 and H2 in your drawing.
1. Which is manipulated variable?
2. Which is the responding variable?
3. What variables are held fixed during the experiment?
4. Why is it a good idea to carry out at least three trails for each value of H1?
5. Why did you take an average numerical value H2?

......Graphing....................

Note: You are going to plot the averages of the tennis ball and the super ball on the same graph. Use colored pencils to identify the ball i.e. green for tennis ball and blue for tennis ball.
Work together and use your notes...................

Answer the following questions:
1. On which axis (horizontal or vertical) did you plot the manipulated variable?
2. On which axis (horizontal or vertical) did you plot the responding variable?
3. Did you plot your data according to the sequence (H2, H1) or (H1,H2)?
4. Is (O,O) a data point?_________________Why?_________________________

Conclusions:

The students will be able to answer the following questions with 80% accuracy.

Bouncing Ball Experiment
1. What type of experiment was this?
2. Is the type of ball qualitative or quantitative?
3. What are the two main variables on this experiment?

Using the graph you just did.........answer the questions 1-4
1. If the release height of the tennis ball is 60 cm, what is the rebound height?
   Did you use interpolation or extrapolation?
2. If the release height of the tennis ball is 160 cm, what is the rebound height?
   Did you use interpolation or extrapolation?
   Check your prediction experimentally. Was your answer approximately correct?

3. If the tennis ball rebounds to a height of 140 cm, from what height was it released?
   Did you use interpolation or extrapolation?
4. If the release height of the super ball is one meter, what is the rebound height?
   Did you use interpolation or extrapolation?

References:

AIMS Program on Geometry and Graphing
CPS Qualitative Approach to Science '93

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Jamal Brown - Daniel Hale Williams

Teaching Arithmetic and Math Concepts To Headstarters

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Objectives:

To help students recognize numbers, compare sizes of objects, and recognize one-to-one correspondence. The students will learn to recognize numbers 1 to 5 as they are named. They will also be able to count up to 5 and place items into groups of one to three as directed. In addition, students will compare objects by size (eg,small, medium, large). These activities are designed for three year old Headstarters at Daniel Hale Williams Elementary School.

Materials Needed:

Blocks
Paper Sticks
String and Beads
Tongue depressors
Construction Paper
Glue
Trays
Puzzles
Story Book

These materials are modeled by the teacher and used by the students in learning centers. The centers are occupied by three children. We will have three learning centers. One center contains blocks. Center two contains puzzles and the third center is the library in which the teacher will read a counting oriented story.

Strategy:

The children will learn through discovery. The teacher will model each exercise by describing what a block is, its color, and the number of blocks that they will use. Next, the teacher will provide string and beads to continue the process. Children will volunteer to discover numbers, counting and the comparing of blocks by size. These activities will strengthen their gross motor skills. Furthermore, the students will glue paper sticks to construction paper under the direction and instruction of the teacher. This exercise will show that the children can interact socially with one another as well understand the basic concept of one-to-one correspondence. Finally, the Assistant will read the storybook to the class; the story contains numbers and objects that relates to placing items into groups. These tasks are helpful in the development of better cognitive skills for children.

Performance Assessment:

Students will perform each task appropriately after the teacher's demonstration. Formally, the children are assessed after 45 days of repeated and consistent exposure to the math concepts. Informally, the teacher is observing each child to evaluate the child's performance on a daily basis. These observations are ultimately declared to a federal agency of the government.

Conclusion:

Students have gained a thorough and basic knowledge of number recognition, one-to-one correspondence, and comparing objects by size.

Reference:

Mr. Jamal Brown: **The Math Doctor** volume 2

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Shirley Hatcher - Daniel Hale Williams

Watermelon Graphing

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Objective(s):

To familiarize primary students with graphing using a bar graph. Identify the parts of watermelon seeds and other seeds. Increase the students vocabulary by using the proper names and common names which refer to the parts of the seeds. To understand further the functions of parts of the seed.

Materials Needed:

Graphing paper, butcher paper, pencils, markers, index cards, and whole watermelon and various seeds (peanuts, lima beans, broad beans, etc.)

Strategy

The teacher will slice a whole watermelon. Then the teacher will divide the students into four groups. Then students will, in aggregate, eat the whole watermelon and estimate how many seeds are in the watermelon. Next the students will get into four groups and count the seeds and calculate the total number of seeds in the entire watermelon. The teacher will cut open a watermelon seed as well as other types of seeds. Other useful seeds are lima bean, peanut, and broad bean. The parts of the seed, which is an embryonic plant, will then be observed, both with the naked eye and with the aid of magnifying glasses. These parts are the hypocotyl, the embryonic stem; the epicotyl, the embryonic leaves; the radicle, the embryonic root; and the cotyledon(s), parts of the seed that serve as a food store for the germinating seed and will be the first leaves of the new plant.

Performance Assessment:

The students should be evaluated on the basis of how accurately they count seeds and complete the graph. They can also be tested on their understanding of the parts of the seed and the function of each part.

Conclusions:

It may also be of interest to contrast fruits that produce single seeds (like peaches) and many seeds (like watermelons). The class can also discuss how seeds and fruits develop from flowers.

References:

Bauer, P.H. et al., **Experiences in Biology** Laidlaw Brothers Publishers,River Forest, IL. (1981), pp. 348-352, 370-371.

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History Of Our Solar System on a Time Line

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Objectives:

The Students will be able to use ratios to make scale models.

Materials needed:

Tape measure or a length of rope, masking tape and a marker or chalk. A space where distance can be measured in a straight line (like a hallway or a sidewalk). A calculator should be used for all calculations.

Strategy:

In the classroom you discuss with your students what a billion years mean. Develop the idea with the students that they need to compare a billion years to something they are familiar with. Suggest that they compare the 4.5 billion years the Earth has been around to 100 feet or 100 meters.

Draw a line on the board and tell the students that this line will represent the start of the Earth to present time. Ask the students where on this line did the dinosaurs exist. Most students will make choices around the midpoint. Note the students choices on the board, come back to these estimates after the students have done the calculation and have plotted points on the 100 foot (meter) line.

Discuss with the class that ratios are comparison of two numbers. Ratios can be written as a fraction. The comparison that is being made is that of Distance over Time; that is, 100 feet (100 meters) over 4,500 million years. Pass out a sheet that has various geological time periods listed. For example the Paleocene period was 65 million years ago. Set up the proportion 100/4500= x/65. When this proportion has been solved for "x", what has been solved is where 65 million would be positioned on the 100 foot line. "x" represents a distance on the time line.

Some examples of times to find would be 200 million years ago. The proportion to write is 100/4500 = x/200. The answer will be 4.44. This means that 200 million years ago will be 4.44 feet from the end of the line that represents present time. Homo Sapiens appears on Earth 350,000 years ago, where will this date appear on this time line? Set up the following proportion 100/4500 = x/0.35. The answer is .0077 of a foot. Mankind's appearance on Earth cannot be measured within a framework of a 100 foot line. If you want man's time on Earth to be represented by one inch of a line, then the proportion you need to set up to determine the length of the line is 1/0.35 = x/4500. The line would have to be 12857 inches long or 1071 feet long (about a quarter of a mile).

Time Periods:
Cambrain period 550 My (Million years) ago. This period is known for the earliest fossils including trilobites.
Ordovician period 500 My ago. The early evolution of fishes.

Triassic period 250 My ago. The rise of the dinosaurs.
Jurassic period 210 My ago. This is the dinosaur heyday.
Cretaceous period 150 My ago. The decline of the dinosaur reign.

Have the students calculate where geological time periods would exist on the time line and have them mark these on the line. Have them write about what they discovered in doing this exercise.

Performance Assessment:

Direct observation of the students setting up the ratios and getting the right value and the plotting of the value on the line.

Have the students draw a 30 centimeter line. This line will represent an amount of time (the last fifty years, last 2000 years...) have the students place dates on the line.

Another ratio problem that the students could do to see if they got the connection between ratios and drawing-to-scale is creating a model of the Sun and planets. If the sun's diameter is compared to 10 feet, what are the sizes of other planets?

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Graphing Speed

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Objectives:

Students will be able to understand how to graph information.

Students will be able to graph a running exercise.

Students will be able to identify the horizontal axis and vertical axis.

Students will be able to compile information to make a graph.

* This lesson is designed for grade levels 3-5

Materials Needed:

Poster Boards

Markers

Stop Watches

Jogging Wear

Gym Shoes

Strategy:

This lesson is designed for each child or group. Students will go outside or in the hallway. Student will list activities in three categories: running, walking, and jogging. Students will use stop watches to time each other. After children have recorded data have them graph each time on poster boards.

* Children can decide on the distance.

* Start lesson with a graph.

Yolanda ran 3 miles in 1 hour, Christeen ran 4 miles in 2 hours and Bob ran 5 miles in 3 hours.

* Allow each group or child to demonstrate their answer.
  Children can use blackboard or paper

Performance Assessment:

Teacher observation and completion of the graph on the poster board.

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History Of Our Solar System on a Time Line

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Objectives:

The Students will be able to use ratios to make scale models.

Materials Needed:

Tape measure or a length of rope, masking tape and a marker or chalk. A space where distance can be measured in a straight line (like a hallway or a sidewalk). A calculator should be used for all calculations.

Strategy:

In the classroom you discuss with your students what a billion years mean. Develop the idea with the students that they need to compare a billion years to something they are familiar with. Suggest that they compare the 4.5 billion years the Earth has been around to 100 feet or 100 meters.

Draw a line on the board and tell the students that this line will represent the start of the Earth to present time. Ask the students where on this line did the dinosaurs exist. Most students will make choices around the midpoint. Note the students choices on the board, come back to these estimates after the students have done the calculation and have plotted points on the 100 foot (meter) line.

Discuss with the class that ratios are comparison of two numbers. Ratios can be written as a fraction. The comparison that is being made is that of Distance over Time; that is, 100 feet (100 meters) over 4,500 million years. Pass out a sheet that has various geological time periods listed. For example the Paleocene period was 65 million years ago. Set up the proportion 100/4500=x/65. When this proportion has been solved for "x", what has been solved is where 65 million would be positioned on the 100 foot line. "x" represents a distance on the time line.

Some examples of times to find would be 200 million years ago. The proportion to write is 100/4500 = x/200. The answer will be 4.44. This means that 200 million years ago will be 4.44 feet from the end of the line that represents present time. Homo Sapiens appears on Earth 350,000 years ago, where will this date appear on this time line? Set up the following proportion 100/4500=x/0.35. The answer is .0077 of a foot. Mankind's appearance on Earth cannot be measured within a frame work of a 100 foot line. If you want man's time on Earth to be represented by one inch of a line, then the proportion you need to set up to determine the length of the line is 1/0.35 = x/4500. The line would have to be 12857 inches long or 1071 feet long (about a quarter of a mile).

Time Periods:
Cambrain period 550 My (million Year) ago. This period is known for the earliest fossils including trilobites.
Ordovician period 500 My ago. The early evolution of fishes.

Triassic period 250 My ago. The rise of the dinosaurs.
Jurassic period 210 My ago. This is the dinosaur heyday.
Cretaceous period 150 My ago. The decline of the dinosaur reign.

Have the students calculate where geological time periods would exist on the time line and have them mark these on the line. Have them write about what they discovered in doing this exercise.

Performance Assessment:

Direct observation of the students setting up the ratios and getting the right value and the plotting of the value on the line.

Have the students draw a 30 centimeter line. This line will represent an amount of time (the last fifty years, last 2000 years...). Have the students place dates on the line.

Another ratio problem that the students could do to see if they got the connection between ratios and drawing-to-scale is creating a model of the Sun and planets. If the sun diameter is compared to 10 feet, what are the heights of other planets?

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The Statistics of M&Ms

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Objective:

The objective of this lesson is to analyze the contents of a bag of M&Ms mathematically. This activity is appropriate for grades one through twelve.

Materials Needed:

One bag of M&Ms peanuts or plain, per student
One small plastic sandwich bag per student
One handout with a circle and a 6x8 grid
Several boxes of crayons
A protractor for each student

Strategy:

Have the students count or tally the number of each color. On the grid, put the appropriate labels on the bottom and left. Make a bar graph coloring a square for each M&M using a similar color.

Do a mean, mode, and median analysis of the candy.

Have students prepare the percentages of each color by dividing the total number of each color by the total number of the contents of the bag. Calculate the number of degrees this would represent. Multiply the percent of each color by 360 degrees.

Use a protractor to measure the number of degrees this represents. Divide the circle accordingly. Color the circle using the same color as candy being represented.

Have the students share their numbers. Compare them. Save this data for comparisons with future classes results.

Performance Assessment:

Depending on the level of the students or class you can evaluate the class through oral participation or in written follow up activities.

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An Introduction to Data Reading and Computations

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Objectives:

This lesson is designed for grade levels 3-5

Upon completion of the lesson, the students should be able to:

- Identify data on the horizontal (x) axis and vertical (y) axis
- Read numbered pounds on a weight scale
- Estimate pounds upon sight before given known weight
- Identify actual weight
- Understand the importance of controlling body weight
- Observe fat, calorie, sugar and sodium intake of certain foods compared with the daily recommended allowances
- Discover and apply rules of computations for determining how much weight to gain, lose or retain
- Design their own data chart

Materials Needed:

- Nutritional Facts brochures of several fast food restaurants
- Bathroom scale
- Calculator (optional)
- Paper
- Writing tools

Recommended Strategy:

- Have students guess the weight of their classmates
- Have students weigh themselves on the scale
- Create a data chart (guessed weight compared to actual weight)
- Choose a routine menu from three of the different fast food restaurant brochures
- Locate the items on the data chart and list the calorie, sugar, fat and sodium intake of each of the chosen items
- Compare the compiled data of a regular menu to the daily recommended allowances
- Decide whether their is a need to lose, gain or maintain weight according to findings after computing totals of data

Performance Assessment:

Demonstrate a usage of how to control weight using basic computation of data chart readings. Incorporate this activity into becoming healthy the mathematical way.

This project is best used in teaching Fitness the mathematical way.

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Counting And Graphing

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Objectives:

This mini-teach has been designed for first and second graders. You may alter it in any way to accommodate your grade level. The main objective is to introduce counting and graphing to students in a phenomenological manner. After completion of this lesson students should feel very comfortable with counting from one to twenty-five. In addition, they will become familiar with two types of graphs: the pie graph and the bar graph.

Materials Needed:

Average size classroom of 20-25 students.

1. Crayons
2. Scissors
3. 2x2-Circles
4. Two 16 oz. bags of Skittles
5. Rulers-one for each student
6. Tape measure
7. Height chart

Strategy:

Start out by asking students if they have ever eaten Skittles before? (Answers will vary.) Then have the students name the five different colors of Skittles. List them on the chalkboard. Pass out the circles and let the students tell you what shape they have. Ask how many Skittles do you think will fit on the circle? (Answers will vary.) Ten will fit. Have them try it and record their answers on the pie graph. The pie graph is divided into ten sections. Student should color the graph according to the colors they actually have on their circle. If a student has 3 reds, (color 3 slices red) 2 yellows, (color 2 slices yellow), etc. Then they can record their answers in a fraction, i.e. 3/10, 2/10, 6/10. Do the same procedure with the rulers. Have students tell you how many Skittles will fit across a ruler. Twenty-four will fit. They will then fill out the bar graph according to the colors they have. If students have 7 greens (color 7 bars green), 10 oranges (color 10 bars orange), etc. Lastly, they will guess how tall they are in Skittles. Have each student stand near the height chart and have them record their answers. Each foot will be equal to 24 Skittles. Therefore, if the student is 3 feet tall, he/she is 72 Skittles tall.

Performance Assessment:

When lesson is completed ask students if they enjoyed the activity. Then let them tell you why. (Answers will vary.) From the pie and bar chart you can see the percentage of colors which showed up the most and the least. With the height chart you can determine who is the shortest person and the tallest person in the classroom.

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Locating IIT Using Ordered Pairs

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Objectives:

(Grade 6)

* To plot and locate ordered pairs in a coordinate plane.

* To understand how to read and create a map.

Materials Needed:

Illinois State Map
Transparencies of a grid
Plane paper grids
Ruler
Unlined paper
Pencils
Map of IIT campus
Overhead projector

Strategy:

Activity I

This activity is best performed if students are seated in rows and seats.

Given a starting point, have each student tell where they are seated. They are to describe their location from a given starting point without using numbers.

Let them discover that they will need at least two numbers to describe their location.

The teacher will plot each child's location on the blackboard. While introducing what a grid is, the teacher will describe the horizontal and vertical axes. The teacher will substitute these names with rows and seats.

Teacher will display a map of a town or city. Discuss how to find locations. Point out that the map is on a grid. Ask students: "What are the four main directions? How is the map divided? Why?" and "How can you find a location?"

Students will be given a map of Illinois and asked to identify locations, given only the ordered pairs.

Students will be given street locations of the map of Chicago and asked to plot the ordered pairs on a coordinate grid.

Activity II

Students will create a map of IIT campus, listing the buildings and their corresponding coordinate pairs. They will create this map using a ruler, plain paper, and a transparency grid.

Performance Assessment:

Students will create a map of their neighborhood on a grid. The map should list all main locations with their ordered pairs.

Conclusions:

Students will understand that the order in an ordered pair refers to directions from the starting point. Students will know that a map is on a grid and grids make it easier to give and follow directions.

Reference:

Burton, Grace M., Hopkins, Martha H., Johnson, Howard C., Kaplan, Jerome D., Kennedy, Leonard M., and Schultz, Karen A.: **Mathematics Plus** HBJ Teacher's Edition Grade 6: Harcourt Brace Jovanovich, Inc. 1992.

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Collecting Data and Graphing

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Objectives:

This is a multi-level lesson.
(A) To see the relationship of student's arm span versus height.
(B) To compare data with their classmates.
(C) To construct a graph using various data and where to plot it.
(D) To work in pairs cooperatively.
(E) To learn to use the meter stick.
(F) To count the number of different colored cubes.

Materials Needed:

2 cm. sq. interlocking cubes, meter sticks, rulers, graph sheets and crayons

Strategy:

(A) To work in pairs to measure arm span and height.
(B) To count the colored cubes and see who has more or less of each color (Comparing).

Performance Assessment:

To check the students' understanding of this experiment with measuring arm span versus height, let the students measure each other with the meter stick.
Graph another classroom with the same age as your class, to compare data.
Drawing conclusions can be learned from both experiments.

Conclusions:

The students will be able to become familiar with these two experiments.
Also, they will learn to graph using the data they have collected and how to use a meter stick.

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Apples A Peel To Me

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Objectives:

For kindergarten and first grade.

1) Students will learn about two different types of graphs:
   a) Real Graphs: using manipulatives and real objects to make a graph.
   b) Representational Graphs: using pictures of real objects to make a graph.
2) Students will learn about the different varieties of apples.
3) Students will learn to gather, record and interpret data.

Materials:

1) Apples, red, yellow and green ones, different amounts of each color.
2) Red, yellow and green crayons for each child, scissors for each child.
3) One copy of the student apple graph sheet for each child.
4) One copy of the apple pictures for each student.
5) Knives, napkins and paper plates.

Strategy:

The classroom teacher will prepare the classroom graphs in advance. Use one graph with the real apples and another graph with the student's preference picture after tasting the apples. This graph will give information about the children's favorite apple choices.

Activity One: Children will guess how many apples there are in the bowl. After they guess the students and teacher will count the apples as the teacher removes them from the bowl or bag. Then the students are asked to sort the apples by color and place them on the floor graph. (discuss graph)

Activity Two: The students are given individual graphs and asked to color in the boxes to match the floor graph. The classroom teacher can remove the apples one by one from the graph as the children are instructed to color in the boxes as she removes the apples. (discuss individual graphs)

Activity Three: The students will taste the three different varieties of apples and asked to pick the apple they like best. Students are given the apple pictures and they will color the picture to correspond to their apple preference. They will write their name on the picture, cut it out and place it on the representational graph. (discuss the graph)

Key Questions:

What words can we think of to describe apples? As a topic opener children can close their eyes and pretend they have an apple in their hands and think about a word to describe their apple.

What is different about these apples? What is the same?

What can we learn from our graphs?

What did we learn from our graphs?

What information is not given in our graphs?

What other things can we do with apples?

Performance Assessment:

Evaluate concepts mastered by class discussion and participation.
Individual evaluation of children's work.

References:

Aims Education Foundation, copyright 1988
(Student pages from Fall into Math and Science)

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History Of Our Solar System on a Time Line

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Objectives:

The Students will be able to use ratios.

Materials Needed:

Tape measure or a length of rope, Masking tape and a marker or chalk. A space that has a 100 feet in a straight line (like a hall way or a sidewalk). A calculator should be used for all calculations.

Strategy:

In the class room you discuss with your students the concept of what does a billion years mean. Develop the idea with the students that they need to compare a billion years to something that they are familiar with. Suggest that they compare 4.5 billion years that the Earth has been around to a 100 feet length. Draw a line on the board and tell the students that this line will represent the start of the Earth to present time. Ask the students where on this line did the dinosaurs exist. Most students will make choices around the midpoint. Note the students choices on the board, come back to these estimates after the students have done the calculation and have plotted points.

Discuss with the class that ratios are comparison of two numbers. Ratios can be written as fractions. The comparison that is being made is that of Distance over Time, that is 100 feet over 4,500 million years. Pass out a sheet that has various geological time periods listed. For example the Paleocene period was 65 million years ago. Set up the proportion 100/4500= x/65. When this proportion has been solved for "x", what has been solve is where 65 million will be position on the 100 foot line. "x" represents a distance on the time line.

Some examples of times to find would be 200 million years ago. The proportion to write is 100/4500 = x/200. The answer will be 4.44. This means that 200 million years ago will be 4.44 feet from the end of the line that represents present time. Homo Sapiens appears on Earth 350,000 years ago, where will this date appear on this time line. Set up the following proportion 100/4500 = x/.35. The answer is .0077 of a foot. Mankind's appearance on Earth cannot be measured within a framework of a 100 foot line. If you want the appearances of man to be represented by one inch of a line, then the proportion you need to set up to determine the length of the line is 1/.35 = x/4500. The line would have to be 12857 inches long or 1071 feet long.

Time Periods:
Cambrain period 550 My (million Years) ago. This period is known for the earliest fossils including trilobites.
Ordovician period 500 My ago. The early evolution of fishes.
Triassic period 250 My ago. The rise of the dinosaurs.
Jurassic period 210 My ago. This is the dinosaur heyday.

Cretaceous period 150 My ago. The climax of the dinosaur reign.

Have the students calculate where geological time periods would exist on the time line and have them mark these on line. Have them write about what they discovered in doing this exercise.

Performance Assessment:

Direct observation of the students setting up the ratios and getting the right value and the plotting of the value on the line.

Have the students draw a 30 centimeter line. This line will represent an amount of time (the last fifty years, last 2000 years...). Have the students place dates on the line.

Another ratio problem that the students could do to see if they got the connection between ratio's and drawing to scale is creating a model of the Sun and planets. If the Sun's diameter is compared to 10 feet, what is the heights of other planets.

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Locating Points Using Cartesian Coordinates

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Objectives:

1. To give the coordinates of a point.
2. To plot a point, given it's coordinates.
3. To use the coordinate system in locating places on the map.

Materials Needed:

Rulers
Chicago City Maps
Graph Paper
Multicultural Handout (Rene Descartes)
Activity Sheets

Strategy:

1. The teacher will ask the students questions concerning how they give directions to get from one place to another. After discussion and finding different responses, pass out Chicago City maps so they show some paths on the map. The teacher will ask the students which important directions they need (N, S, E, W).

2. Introduce the Cartesian Plane by drawing two number lines on the board intersecting at zero. Explain information concerning the Cartesian Plane (origin, positives and negatives, quadrants, etc.). Discuss the term **ordered pair**.

3. The teacher will assist the students in locating points on the plane, by giving some examples on the board.

4. The students will give the coordinates of points on the plane.

5. The students will plot points on the plane.

6. Given three vertices of a rectangle, students will find the coordinates of the fourth vertex.

7. Make two groups play coordinates Tic-Tac-Toe on the board. The rules of the game follow the regular Tic-Tac-Toe rules, except that one group must get four points in a line.

Performance Assessment:

Draw a map of your neighborhood showing places such as schools, churches, post office, etc. In giving directions, apply the skills learned about coordinates. (Hint: one block = one unit, and N, S, E, W imply positive and negative directions).

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Getting the Goods on Graphing

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Objectives:

To graph ordered pairs in the coordinate plane
To identify ordered pairs in the coordinate plane
To write the coordinates of points shown on a plane
To create designs or pictures using ordered pairs

Materials needed:

Graph paper (3 or more sheets per student)
Rulers (1 per student)
Pencils (1 per student)
Overhead projector
Overhead projector transparencies
Maps (2 per student)

Strategy:

Give each student a map that has the index and grid markings removed. Instruct the students to locate certain points. After a brief span of time, distribute the maps with indexes and all markings in place. Again, instruct the students to locate certain points. Lead the students to discover the usefulness of grids.

Distribute graph paper. Have the students construct a coordinate plane. Demonstrate on the overhead projector. Label the axes, stressing that the horizontal axis is x and the vertical axis is y. Explain the point of origin and the negative and positive x and y locations. Allow sufficient time for students to practice locating points and naming coordinates.

Have the students locate ordered pairs on their graph paper and connect the points in order. Plan for the connected points to form a geometric figure.

Prepare in advance a different set of ordered pairs for each student. Plan for the resulting figures to coincide with a current event, holiday, or school program. Display the finished graphs in a prominent place.

Performance Assessment:

Each student will create his or her own picture or design on graph paper and write the ordered pairs. The ordered pairs will then be given to other students. The student who created the design will be expected to correctly write ordered pairs that will duplicate the design. The student who graphs the ordered pairs will be expected to correctly duplicate the design. Both of these performances should be completed with 95% accuracy.

Conclusion:

The students will realize that the skills they have acquired will be useful in many areas besides mathematics. Other disciplines that utilize graphs are science, geography, economics, and computers. With the use of and interest in computers continuing to grow, students will be made aware of a career choice in computer-aided design (C.A.D.).

Multicultural Statement:

Africans invented rectangular coordinates by 2650 B.C. and used them to make scale drawings and star-clocks in ancient Egypt.

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Introduction to Curve Stitching - Line Designs

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Objectives:

To develop the students' awareness that straight line segments can produce the illusion of a curve.

To develop the students' ability to recognize and describe number patterns.

To experience the beauty of mathematics and to introduce geometric fundamentals.

Materials needed:

1/8" hardboard squares approx. 10" x 10" (or 24cm x 24cm) for each student.
1/8" hardboard figures (equilateral triangle, regular pentagon, regular hexagon, circle) one shape for each student.
11" pieces of brightly colored yarn (approx. 25 pieces per figure).
Overhead projector transparencies of suggested designs for each figure.
Plastic demonstration figure (optional).
Observation worksheets - one per student.

Strategy:

Obtain the 1/8" hardboard at a major hardware store. Hardboard usually comes in 4ft. x 12ft. sheets. However, most stores can section it for more convenient transport. A shop teacher or student/parent can assist with cutting 10" x 10" squares if power tools present an area of difficulty. Tracing large regular polygonal shapes on the hardboard with pencil will make cutting simpler.

Once the shapes are cut, measure and mark each side so as to obtain 8, 10, 12 or 15 divisions as you desire. Each mark will then need to be notched with a saw to create a 1/4" slit.

Line designs are formed by connecting sequences of notches with yarn pulled taut as a line segment. The basic pattern is to connect equally-spaced notches along the two adjacent sides of a square:

```
 8 |-
 7 |-                    (1) Divide each side into an equal number of
 6 |-                        segments, notch and number them.
 5 |-
 4 |-                    (2) Connect notch "8" on the vertical with
 3 |-                        notch "1" on the horizontal.
 2 |-
 1 |-                    (3) Connect notch "7" on the vertical with
    -+-+-+-+-+-+-+-+-+-      notch "2" on the horizontal and so on
     1 2 3 4 5 6 7 8         until all pairs of notches whose sum is
                             9 are connected.
```

A greater number of notches on the side of the square will result in a design which is higher in density but has the same curve. The numbering of the notches can be varied to create different number patterns or can be used to discuss the Cartesian Coordinate System. Another variation is to use a rectangle and divide each side into the same number of equal parts.

An effective approach to teaching this lesson could include using cooperative learning groups of two. The teacher would demonstrate the line segment connection (a few segments) on a model at the overhead projector, discussing number patterns, if desired. One student from each group can then obtain their "notched" square and yarn bundle. Squares should be notched on all sides to allow each student to complete their own line design. Once the squares are completed and discussed, each group can obtain a second polygonal shape for creative experimentation. Suggested designs can be shown on the overhead projector or copies made to hand out with the polygonal shapes.

Conclusions:

While the mathematical concepts built into this lesson are important, it is equally important that students see that mathematics underlies much of the design and art of our modern culture. Students find much joy in expressing their creativity through these line designs. Since few prerequisite skills are required, students who have failed in previous mathematical activities find success and recognition on par with or above high achievers.

References:

Dale Seymour, Linda Silvey and Joyce Snider. LINE DESIGNS. Palo Alto, Calif.: Creative Publications, 1974.

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Junk Food Math

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Objective:

The main objective of this miniteach is to teach 3rd through 4th grade students estimation and introduce percentage.

Materials:

For each student:

- one zip-lock bag containing 75 randomly chosen Skittles candies and 5 small paper cups

- classroom set of centimeter grids for graphing results

- worksheet prescribed with a circle in which 75 Skittles can be placed

- worksheet with directions

- box of 8 crayons

Recommended Strategy:

. Distribute zip-lock bags containing Skittles and paper cups.

. Take out paper cups.

. Estimate amount of each color Skittles.

. Record estimated numbers.

. Count all Skittles and record total.

. Place Skittles by color into paper cups.

. Count Skittles by color and record actual amount of each color.

. Compare sets of candies by color using the less than, greater than, and equal signs.

. On centimeter grid, list colors along horizontal axis.

. On centimeter grid, list numbers from 0 to 25 along vertical axis.

. With corresponding color crayon, color bar graphs to represent the number of each color candy found in the sample.

- Use formula:

  $$\frac{\textbf{Color Number}}{\text{Total Number}} \times 100$$, to calculate the percent of each color.

- On prescribed circle worksheet, form a pie-shaped wedge out of the predominant color.

- Next to the preceding wedge, form another pie-shaped wedge out of the next most frequently occurring color.

- Continue making pie-shaped wedges until all colors are used and the circle is filled.

- Label each pie slice with the percentage number which it represents.

- The "Junk Food Pie" may then either be eaten by the student or the pieces may be glued to the paper to keep a permanent record of the results.

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ROTATIONS

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OBJECTIVES

The student will:
1. Define rotation as the composite of two reflections over intersecting lines.
2. Identify rotation images of a figure.
3. Recognize and apply the properties of rotation.

EQUIPMENT AND MATERIALS

Rotogram
Overhead projector
Markers for overhead
Transparencies of figures showing reflection, translation, and rotation.

RECOMMENDED STRATEGIES

Demonstrate and review concept and properties of reflection and translation. a) There is a one-to-one correspondence between points in a plane and their reflection through a given line. b) Reflections of a set of points through a line preserves co-linearity, distance, and angle measure. c) Line reflection changes the orientation of a figure. d) Translation preserves orientation of a figure.

Introduce rotation as a composite of two reflections across intersecting lines. Show this using transparencies, rotogram, coins, and other objects available to you. Emphasize that since rotations are composites of reflections; the properties are similar to reflections and translations.

Provide additional opportunities for reinforcement of concepts using worksheets.

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Graphing Equations From Software

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Harlan H.S.
821-2800

Objectives:

1) TO REINFORCE PREVIOUSLY LEARNED EQUATION GRAPHING SKILLS.
2) TO DEVELOP NEW STRATEGIES --OTHER THAN MEMORIZING EQUATIONS--FOR EQUATION GRAPHING.

Apparatus Needed:

1) AN IBM-PC OR COMPATIBLE COMPUTER,
2) AN OVERHEAD PROJECTOR,
3) A VISUAL APPARATUS FOR PROJECTING THE COMPUTER'S CRT IMAGE THROUGH THE OVERHEAD TO THE SCREEN,
4) THE SOFTWARE 'GREEN GLOBS'.

Recommended Strategies:

Students should observe the demonstration of 'Green Globs' by the teacher as he/she takes them through each segment of the software. They should be encouraged to plot their own equations using 'Equation Plotter' and watch the graph pattern change as they discover what happens if they multiply the equation by two, three or 'n'; or what happens if they add, subtract or divide the equation by some number.

The students should separate into small groups to develop their skills with 'Linear Graphing.' They should be encouraged to look at the answer when they are stuck rather than resort to memorized formulas. The idea is to develop their own new strategies in determining line equations.

The students should be encouraged to improve their scores when playing the games 'Green Globs' and 'Tracker.' The games should be self-motivating. The student's proficiency with graphs should improve radically as their game improves.

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Mathematics/Physics

The Cuisenaire Four-Pan Algebra Balance: Limitations and Suggestions

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Objective(s):

Many teachers use a physical or metaphorical balance in presenting the performance of equivalent operations on both sides of an equation. The design of the Cuisenaire balance (see illustration) facilitates the teaching of these and other algebraic properties using both positive and negative numbers. The purpose of this lesson was: (1) to expose middle- and high-school teachers to its use as described in the manufacturer's instructions, (2) to explore with them any problems or limitations, and (3) to brainstorm, discuss, and evaluate ways to use the balance in the teaching of other concepts or properties.

Materials:

- 1 traditional two-pan balance
- 1 or more Cuisenaire Four-Pan Algebra Balance(s)
- Chips and canisters (included in kit)
- Instruction booklet (included in kit)
- Sample problems

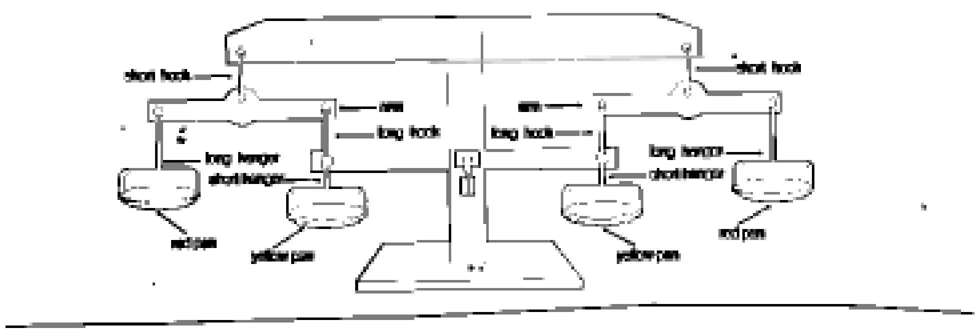
Strategy:

The lesson began with an interactive discussion regarding the intuitive connection between equations and balance. Participants shared ways they had incorporated this concept in their own teaching. Some had used an actual scale, and they were asked to model this using a two-pan balance. They were then given a simple problem involving addition or subtraction of a negative term, and asked to model it using the same balance. It quickly became obvious that this was not possible without rearrangement of terms and use of the "subtraction = adding the opposite" rule (or its converse), contradicting the introductory nature of the lesson.

Participants then watched as the Four-Pan Balance was put together, and commented on the differences from a traditional balance. In particular, the upper beam is fixed; from each end, a short arm is attached through its middle, with a pan hanging from each end of the arm. This would create two individual balances, except that the inner pan of each is further connected to a long arm passing through the perpendicular shaft containing the balance indicator. The effect is to make all four pans interdependent at all times.

Next, it was explained that the inner pans would represent positive values and the outer pans, negative. The terms of an equation are represented by putting the appropriate number of chips in each pan. Variables are represented by canisters, which are filled ahead of time with the number of chips corresponding to the solution, less one (to account for the weight of the canister). Using examples from the instruction manual, operations such as adding opposites, adding and subtraction of integers, and solving linear equations were modeled.

Finally, participants were encouraged to suggest problems and ways to use the balance in their solution. They were also asked to experiment with properties or problem-types not demonstrated in the manual, and to note any difficulties, either practical or conceptual.



Performance Assessment:

Participants were given random assignments from a list of problems and properties to demonstrate on the balance, some of which were expected to be impractical, if not impossible. They were asked to explain their strategy, and comment on any advantages or limitations they saw to using the balance as opposed to another method.

Conclusions:

Participants were excited about being able to extend the concept of balance to equations containing both positive and negative numbers. The Four-Pan Balance seemed especially appropriate for exhibiting the Zero Property (a + -a = 0), addition or subtraction of two numbers, and solution of simple linear equations (those not requiring combination of like terms). Some pointed out possible confusion once the canisters are introduced: having to allow for their weight takes away (albeit slightly) from the conceptual simplicity. Also, space on the pans and numbers of chips and canisters limited the demonstrations to problems containing small integers. This was not a problem as long as the object was to demonstrate basic properties, rather than to solve problems. Also, it was felt that merely watching the instructor demonstrate was not nearly as effective as actually doing it themselves. This raised the question of how many balances it would be necessary to purchase per class for it to be a worthwhile investment.

The general conclusion of the participants was that they would be enthusiastic about using the Balance to introduce algebraic concepts, if they could afford a class set. However, they would be impractical to use in routine problem solving after the introductory period. This was not seen as a major drawback, since the objective of a lesson should be to master the concept, not the use of the teaching tool. The Balances can be brought back out when introducing the Multiplication and Division Properties of Equality, and even combined when solving systems of equations, but they should not be used on a daily basis in the way we use calculators, for example.

References:

Kung, George and Vicchiollo, Ken, Four-Pan Algebra Balance (1997)

Instruction manual included with the kit. May be ordered from:

Cuisenaire Company of America, Inc.

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White Plains, NY 10602-5026

Sorting Pennies, A Wagering Activity for Algebra 1

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Objectives:

To abstract the idea of a line.
To introduce other methods of solving simultaneous equation besides graphing.
To develop problem solving skills.

Materials Needed:

A scale able to read (to the nearest tenth of a gram) up to 400 grams
at least 1,000 pennies
a plastic cup to hold pennies on the scale
numbered plastic ziplock bags 1 through 8
16 index cards, 2 per ziplock bag

Strategy:

The following instructions are directed to the instructor:

Place the 1,000 pennies in a large pile on the front desk along with the scale, the plastic cup and the ziplock bags. Divide the class into 8 groups. From each group have one member come up and take a handful of pennies. Weigh and record the amount 'W'. Place the weighed pennies in the corresponding ziplock bag and give the group member the instructions to separate the pennies into two groups: 1981 and before 'B', 1983 and after 'A'. They are to record the number of each kind of penny on one of the index cards provided and keep it from your view. On the other index card, they are to write the total number of pennies in the bag 'T'. Place this second index card and all pennies in the plastic bag and return to front desk. As the bags are returned record the number of pennies and calculate the predicted number of pennies for 1982 and before for each group. When all the pennies have been returned and the calculations finished, announce that through the miracle of algebra you know how many of each type they have sorted with a margin of error of plus or minus two pennies. (I find a small wager, if possible, with each group enlivens the activity). Collect your winnings and explain to the class why you won.

Pennies for 1981 and before weigh 3.1 grams
Pennies for 1983 and after weigh 2.5 grams
(Note: avoid 1982 pennies because the mint produced some of each.)

	Number	Weight	Total Weight
1981 and before	B	3.1	3.1B
1983 and after	A	2.5	2.5A
before and after	T		W

Which gives us the equations:

$$3.1B + 2.5A = W$$
$$B + A = T$$

The problem becomes just finding the intersection of two lines.

Solving by Substitution: $A = T - B$

$$3.1B + 2.5(T - B) = W$$
$$3.1B + 2.5T - 2.5B = W$$
$$0.6B + 2.5T = W$$
$$- 2.5T = - 2.5T$$
$$0.6B = W - 2.5T$$
$$B = (W - 2.5T) / 0.6$$

I use this activity after I have taught the graphing of two lines and finding their intersection but before other methods of finding the solution of systems of equations. This is an introductory lesson that abstracts the intersection of two lines to find a solution.

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Trigonometric Functions

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Objectives:

To define and demonstrate the six trigonometric functions
To facilitate using the three most frequently used trigonometric functions

Materials Needed:

Pythagorean Theorem Model Overhead
Overhead Projector
Overhead TI81 Graphing Calculator
TI81 Graphing Calculator/Individual
Spaghetti (12 pieces for each individual) four 3, 4 and 5 cm lengths/each
Glue
Centimeter Grid/Individual
Compass and Protractor

Strategy:

1. Discuss the Pythagorean Theorem
2. Demonstrate the Pythagorean Theorem using spaghetti
3. Calculate 6 word problems demonstrating the Pythagorean Theorem
4. Discuss the trigonometric functions
5. Calculate the same 6 word problems demonstrating the trigonometric functions
6. Discuss how the trigonometric table is formed
7. Graph the sine and cosine functions
8. Demonstrate the plotting of sine, cosine and tangent on the graphing calculator
9. Discuss how the answers obtained using the Pythagorean Theorem and the trigonometric functions compare
10. Demonstrate a Real Life Problem by measuring the height of the wall in the room using the tangent function

Conclusion:

1. The Pythagorean Theorem gives us the third side of a right triangle when two sides are given. The trigonometric functions give all sides and angles of a right triangle when one side and one of the acute angles are given. It was demonstrated to the class how to find the three sides of a triangle when two sides are given. This was done by using the Pythagorean Theorem and the trigonometric functions.
2. Trigonometry allows calculation of the measures of angles in a triangle when the length of certain sides are known. While we studied right triangles, trigonometry can also be applied to arbitrary triangles.

References:

Algebra 2 (Prentice Hall Mathematics 1990)
Contemporary's Number Power 3 (The Real World Math, 1988)

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Equalities And Inequalities

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Objectives:

1. to involve students in discovery
2. to teach partitioning and equivalency
3. to teach the order of fractions

Materials needed:

Overhead projector (teacher)
Tower of bars (class)
Rulers (class)
Markers: Bingo chips, candy, etc. (class)
Activity cards (one per group of three)

Strategy:

The tower of bars is a model for fractions. The whole bar at the top represents the unit 1 and the bars below it illustrate fractions with denominators from 2 through 12. Various fractions can be illustrated by placing markers on the tower of bars, such as three markers on the seventh bars to represent 3/7 and so on.

Place a transparency of the tower of bars on a overhead projector. Discuss numerator and denominator using tower of bars. Stress the number of equal parts determine the denominator and the numerator tells how many equal parts are being considered. Divide class into groups of three. Each individual will have a copy of the tower of bars, a ruler or straight edge and markers. One student will have the responsibility of demonstrating the model by placing markers on the overhead projector. Another would write the fraction on the chalkboard and the third student would lead discussion of observations and/or explanations regarding the model. Activity card 1, for example, would be a practice to reinforce the part-whole interpretation of a fraction, such as, 3/5 indicates that a whole has been partitioned into 5 equal parts and 3 of those are being considered.

Equalities: every second row on the tower of bars has a line down the center. That is, a line appears down the center of the halves bar, the fourths bar, the sixths bar and so on. It may be helpful to color these lines on a transparency. On another activity card students would place a ruler on the line down the center and use markers to show the patterns on every second line. Then, write the fractions seen using the equal sign. The corresponding numerical pattern is 1/2 = 2/4 = 3/6 = ... Every third row has vertical lines that line up with those on the thirds bar. These lines can be colored a second color. Similar observations can be made for every fourth bar, every fifth bar and so on. The corresponding numerical patterns are 1/3 = 2/6 = 3/9 = 4/12 ... and 2/3 = 4/6 = 6/9 = 8/12.

To help see the equality pattern, markers can be placed on bars and a ruler or the edge of a piece of paper can be used to match up vertical lines. Additional activity cards can be devised to make this discovery.

Inequalities: The first part of each bar as you move down the left side of tower of bars represent a unit fraction and these parts become smaller and smaller. Similarly, looking down the right side of the tower of bars shows that 1/2 < 2/3 < 3/4 < 4/5 .... These fractions get closer and closer to one. Activity cards can be devised to show this and other patterns of inequalities.

The lesson may be concluded by summarizing concepts discovered from the use of the activity cards and the vocabulary review. Suggested terms are: numerator, denominator, equivalent fractions, unit fractions; symbols: < is less than, > is greater than, = is equal to.

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Draining The Swimming Pool

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Objectives:

To do some experiments that suggest a way to solve the general work problem:

If A can do a job in X hours and B can do the same job in Y hours, how long will it take A and B working together to complete the job?

More specifically, if one pipe can drain a swimming pool in 4 hours and another pipe can drain the pool in 7 hours, how long will it take to drain the pool using the two pipes together?

Apparatus Needed:

Plastic container holding 2 or 3 liters, several plastic tubes of different inside diameter (eg. 1/2", 1/4", 3/16") each about 4 feet long, stopwatch or clock with second hand, several pails for holding water.

Transparencies

Use overhead to show fractional parts of container drained in a given number of seconds.

Recommended Strategy:

The equation given in textbooks to solve the swimming pool problem is usually stated as X/4 + X/7 = 1. It is not immediately obvious why this formula works or how it was derived. The following is a strategy for leading up to the formula.

Determine the number of seconds or minutes it takes to drain the same amount of water from the plastic container using each of the plastic tubes separately. You can ask for student volunteers, one to hold a tube and another to siphon the water. Students at their desks can use the clock to determine the times. Have the students write down the times next to the i.d. of the tubes. Many questions can be raised along the way. For example what is the relationship between the i.d. of the tube and the draining time for that tube? If the radius of the tube is doubled what happens to the inside area of the tube, the amount of water it will carry and thus the draining time? Make estimates and then test them using the appropriate tube. An important question is what fraction of the container is drained by one or more tubes in 1 sec. Suppose the draining times for two tubes are 25 and 40 sec. Then in 1 sec., (1/25 + 1/40) of the container will be drained. Ask the students to find a proportion using this idea. Hopefully after a few minutes working in groups they will come up with this proportion: (1/25 + 1/40) / 1 sec = 1 / X sec , where X is the time to drain using two tubes at the same time. Now choose two tubes, do the experiment and see if the time you get agrees with the solution you get using the equation. The equation given at the beginning follows from the proportion.

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Inequalities

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Objectives

Students will learn how to transform inequalities and find their sets.

Apparatus Needed:

Math balance, and two rings connected to several rubber bands.

Recommended Strategies

The procedure starts out with a discussion on the usefulness of numbers. It should be pointed out that a number is a very abstract concept and we talk about them in solution sets. Its usefulness can be reflected on a number line to indicate quality and operation.

In the sciences, positive and negative numbers can be used in connection with temperature readings, linear forces, clockwise and counterclockwise motion, positive and negative charges of electricity, acceleration and deceleration, etc.

In the directional sense they are useful in indicating north and south, east and west, above and below sea level, left and right, and up and down.

The stock market uses them to show changes in prices. They are used in everyday statistics to indicate changes such as the increase and decrease in the cost of living,and to show deviation from the normal - as in weather reports. Statistics in sports and scoring of games often require the use of signed numbers.

This particular math model is constructed by dividing a horizontal bar into equal parts. A point of division is taken as the starting point or origin and labeled zero. Each point to the right of the zero is labeled with a positive number: +1 representing the first unit, +2 the second unit etc. Every point to the left of zero is labeled with a negative number beginning with -1. There is a hook at each point to help identify the number.

To emphasize the ideas of oppositeness, position and direction, students realize that the direct value of a number is its absolute value along with the element of direction.

Now we work with examples. We add on the number line until we are able to perform the operation readily.

Next I asked what happens when each member of an inequality is **multiplied** by a nonzero number? Multiplication by a positive whole number is presented as repeated addition. Multiplication with negative numbers are motivated by algebraic laws.

Finally, we motivated the method for solving linear inequalities.

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LINEAR EQUATIONS

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OBJECTIVES

1. Students will emulate the steps in solving linear equations by means of a manipulative.
2. Students will be able to transfer the operations performed on the manipulatives in equation form.

EQUIPMENT AND MATERIALS NEEDED

Overhead Projector/Marker
Twenty-five Black Squares (Overhead Set)
Twenty-five Clear Squares (Overhead Set)
Ten Black Circles (Overhead Set)
Ten Clear Circles (Overhead Set)
Thirty cubes and ten dixie cups of same color (Classroom Set)
Thirty cubes and ten dixie cups of a different color (Classroom Set)
Classroom set of "Work Area Sheets"
One balance scale

RECOMMENDED STRATEGY

Using the overhead, present a short set of notes with a definition and interpretation of an equation. Ask the students to distinguish between given examples of an expression and an equation. Using the overhead black and clear squares (which represent unit integers) and black and clear circles (which represent unit variables) create an equation. Present the two rules: 1) In order to remove a clear square (negative integer) you must add a black square (positive integer). Stress that the colors are opposite. 2) The same number of color squares must be added to **both sides**. Stress balance. For example the equation $x + 6 = -2$ with manipulatives would be solved in the following manner. A black circle and six black squares would represent $x + 6$ and two clear square would represent -2. Step 1) Add six clear squares to the left side (stress opposite). 2) Add six clear squares to the right side (stress balance). 3) Write an equation of steps one and two. ($x + 6 - 6 = -2 - 6$) 4) Eliminate the squares on left side. 5) Combine the squares on the right side. 6) Write an equation of the results of steps four and five. 7) Results: One black circle equals ten clear squares, or $x = -10$. Present several examples on the overhead.
Ask the students what would happen if they did not add the opposite to **both** sides. Use the balance scale to demonstrate the results. Then give the students their own set of manipulatives and have them solve equations.

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Algebraic Addition

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Objective

To re-invent the wheel in a manner so that there is:

1. Transfer from other knowledge of the student;
2. Minimal relationship to previous math;
3. Conventions of Minus used in business.

To get the student to realize the rules of signs without the turn-off that he/she may have gotten previously.

Apparatus Needed:

Play money
Play IOU's
Dice One red, and one black for each student

Procedure

Before class give several students the play money, and IOUs. After attendance take a loan from one of the students and have that student take a loan from another.

On the overhead list each student's holdings. Have the beginning balance and the transactions using the brackets to stand for negative--(but using the terms owned, and owed, the accountants use debits as +[owned] and ( ) for -[Owed]--By having the students borrow from each other to give the teacher the money there will be a negative number--the student owes more money. A sub objective could be to balance the student's own check book.

For practice problems have the students make their own by rolling the dice. The black being + and the red being -. Thus they will have random problems especially suited for the slower student since the numbers will be less than 7, and not zero. This can later lead to some motivation for statistics and surely will delight some of the gamblers in the class.

Conclusion

Since this approach was thought of in the SMILE program and not tested in the actual classroom I am presenting it as an alternative for the slower classes, possibly a support class. I have used the text book method, then, for the students still having trouble, passed out the rules to rote memorize, and, while working with the individual student invoked a loan approach (borrow, and "paid" so as to end up with money owed). Maybe starting with this approach we can work around the students' inconsistency of minus, and negative.

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Simplifying Equations of the Form ax+b=cx+d

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Objective(s):

(1) Students will be able to solve equations of the form ax+b=cx+d.

(2) Students will be able to visualize the concept of "balancing" an equation.

Apparatus Needed:

Balance scale (easily obtainable if you have an understanding and cooperative science department)
Assorted weights (I adapted a box of Cuisenaire rods)
Yard stick (optional)
Small stuffed animal or soft rubber toy (optional)
Assorted "unknowns" (any objects that are of an unknown weight but can be weighed as a combination of rods)

Recommended Strategy

As a link between this lesson and previous lessons, I started with a review of the four basic types of equations, i.e. equations that can be solved by adding, subtracting, multiplying or dividing. I differentiate between the four types so that the students can remember them more easily by associating them with the four basic operations. Others have argued that there is only two or three basic types. I leave the final decision up to you.

After this short review and discussion of methods for solving these types of equations, we show a more complicated equation of the ax+b=cx+d form and ask the students for suggestions on how to solve it based on present knowledge. After students have had an opportunity to give input on the solution, we demonstrate how equations can be displayed using a balance scale.

Balance Scale Demonstration:

Using the Cuisenaire rods, set up a situation you know is equal. For example, 4 light green rods with 4 white cubes weighs the same as 2 light green with 10 white cubes. Place these different combinations on opposite sides of the balance scale and watch as the scale balances (experimenting before is highly recommended to avoid an embarassing situation). Then ask the students what would happen if you started to remove pieces from different sides, (Desired response: the balance is upset). Next ask the students, "What should I do to put the balance back?" (Desired response: Whatever you did to the first side, now do to the other). Continue in this manner until the following situation is reached: 2 light green rods are balancing 6 white cubes. Now say, "If 2 green rods balance 6 white rods, what would happen if I took out half of the green rods?" (Desired response: Balance upset). Next say, "What should I do to restore the balance?" (Desired response: Take out half the white cubes). Upon doing this, the solution is now evident: 1 light green rod equals 3 white rods. Try this again with different combinations of rods (Again, experiment beforehand). As you go through each step, write on the board what the situation on the scale is, but in equation form, i.e. 4 light green with 4 white cubes balances 2 light green with 10 white cubes would become 4g+4=2g+10.

After a few attempts, show that they are merely doing the same manipulations that they did on the basic 4 types with the following conditions: Adding or subtracting is done first with multiplication or division done last, each step should make the problem simpler than before and the ultimate end is to have all the unknowns on one side and all the constants on the other. Once this condition is met, the final step is to multiply or divide by some constant.

This demonstration can be made more dynamic by allowing individual students to try their hand at the manipulations to produce equivalent situations. Other objects may be used as unknowns as students experiment to find other true statements.

At the end of the lesson and as a taste of what is to come, I might use the yard stick and the stuffed animal to set up a situation to demonstrate inequalities. Place the yard stick so that half is on the desk (Use the stuffed animal as a weight by placing it on the end of the yardstick on the desk) and the other half off the desk. Then proceed to strike the free end of the yardstick sending the stuffed animal flying (experiment beforehand to be certain that the yardstick is strong enough and the stuffed animal light enough to make the flight). I then ask, just as the bell rings, "Why did the animal fly?". Without answering, class is dismissed and as they are leaving I tell them we will be discussing what they saw in our next class, which will be on inequalities.

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Rules of Sign Change

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Objectives:

1. This is aimed at 7th and 8th grades as well as pre-algebra and 1st year algebra students.
2. Understand the operation of plus and minus signs during arithmetic operations.

Apparatus Needed:

1. **Number Line Materials**
   1.1 Number lines for each student printed across the whole paper. The lines must be spaced far enough apart so bingo markers cover only one line at a time.
   1.2 Need translucent bingo markers, maybe 5-10 per student.
   1.3 Need one acetate sheet with a number line to work with an overhead projector.
2. **Function Machine**
   2.1 Cardboard or wood cutout representing a machine, titled **"Function Machine"**. It can be as elaborate or as simple as you wish to construct it.
   2.2 Strips of cardboard or other material one of which will go into the machine from the top the other will come out from the side.
   2.3 Crank on the machine which is either functional (pulling through the top strip and pushing out the bottom strip) or turned just for show
3. **Keep It or Give It Game**
   3.1 Two dice, each of a different color.
   3.2 Sheet of equations, probably about 100 with positive and negative numbers with addition and multiplication operations.

Recommended Strategy:

1. **Number line strategy** - shows positive and negative numbers as directions on the line, negative left, positive right. Explain the difference between negative numbers and subtraction, i.e. a bill for $8.00 is a negative number, it is money owed and you do not have; getting $10.00 and paying $8.00 to satisfy the bill is subtraction, transferring money you have leaving yourself with $2.00.
   Experiment with the number line using an overhead (with the students working on their own number line papers). I.e. move 10(right) move -5(left) all should be on 5(positive side of the number line). Continue with a few more examples to show direction, and how to use it. **Note:** use a couple of examples of subtracting negative numbers, using reversal of direction for subtraction, so negative numbers subtracted will move in a positive direction.
   Experiment with multiplication using the number line, also show a consistent pattern on the board so two methods reinforce sign

rules.

Example:

The products show a difference of 4 at each succeeding multiplication.

| 4·4=16|,
| 3·4=12|,
| 2·4= 8|,
| 1·4= 4|,
| 0·4= 0|,
|-1·4=-4|,
|-2·4=-8|;

To show negative times negative is positive use pattern of:
use the number line using direction to show results. The reason for using more than one bingo marker is to show the pattern on the number line.

| 3·(-4)=-12|,
| 2·(-4)= -8|,
| 1·(-4)= -4|,
| 0·(-4)= 0|,
|-1·(-4)= 4|,
|-2·(-4)= 8|;

It is recommended the 1st number represent the multiple of the 2nd number, i.e. 3x4 means 4+4+4 not 3+3+3+3. Even though multiplication is commutative, it will be easier, in algebra, to show that 5w is 5 times w, meaning w+w+w+w+w.

2. **Function Machine** - This is used as reinforcement to calculate with both positive and negative numbers. A strip of cardboard is marked off with

| 1 | 2 | 3 | 4 | 5 | etc.| and this is fed into the input of the machine (which is cardboard or wood, etc. painted or marked to be a machine), the 1 being fed in first. There is a 2nd cardboard which is the output for example;

| 2 | 4 | 6 | 8 | 10 | etc.|

which the students have to guess, after seeing one or two examples, at what the output will be and what function is making this output, this case is input times 2. Make different strips for input and output. The function can be as complicated as (input - 3) times -2.

3. **Keep It or Give It Away Game** - This is used as reinforcement for the operations of positive and negative numbers. The class can be divided into 6-groups. Each group starts off with 50-points. The team reaching 100-points first wins. A paper with 100+ equations on it, with the first 6 equations numbered 1-6. Teams go in order, team number 1 starting. Two dice used, each of a different color. One die determines what team will get the equation if the original team gives it away. The other determines which equation is solved. After an equation is used the next equation on the list (other than the original 6) will replace used equation. The team tossing the dice has 10-seconds to decide to keep the equation or give it away (teams want positive results and give away negative results). The team getting it has 30-seconds to give the correct answer. The evaluation of the equation are the points involved, i.e. 8·(6-3)·(-1), result is -24 points. If it was 4th on the list the next equation goes into the 4th slot, etc. If the original team rolls 4 on the give dice then team 4 gets the equation if the original team: 1) runs out of time, and result is positive 2) wants to give it away; or 3) wants it but gives the

wrong evaluation and result is positive; else the original team gets the points. Any other rules or changes can be made. Gear the rules and the equations to the level of the class, it should be enjoyable as well as educational.

Note: - The students should not be rushed to give instant answers. Perhaps count 3-seconds before allowing any student to answer.

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Using the Balance

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Objectives:

Given an equal arm balance the learner will determine the mass of an object by comparing it with the mass of objects whose mass in grams is known.

Given graph paper the learner will construct a bar graph.

Apparatus needed:

Overhead projector {Optional}
1 equal arm balance {Commercial or homemade}
3 objects of different masses
5 small washers { 2 g }
5 medium-size washers { 5 g }
5 large washers { 9 g }
graph paper
modeling clay { 15 g }
Lab worksheet

Recommended strategy:

The overhead projector was used to review the following vocabulary:

variable	balance
manipulated variable	mass
responding variable	

A graph was constructed on the transparency to review these terms:

interpolation	vertical axis	plot
extrapolation	horizontal axis	

The lab worksheet contained the procedures to follow, a Data Sheet which included space for a labeled drawing of the experiment, Tables 1 and 2, and comprehension questions.

PROCEDURES;

1. Make sure the arms are balanced before measuring each object.
2. Place one object in the left pan of the equal arm balance. Place any number or combination of washers in the right pan until the

two pans are level, or balanced. When the two arms balance, the mass of the object is the same as the total mass of all the washers.

3. Record the name of the object under **Type of Object** on Table 1 on the Data Sheet.
4. Count the number of washers used and record them under the correct headings on Table 1.
5. Multiply the number of 2 g washers by 2, the number of 5 g washers by 5, and the number of 9 g washers by 9.
6. Add the three answers together and record the sum under **Total Mass, TM**.
7. Repeat the same procedures or steps with the other two objects.
8. Construct a bar graph.
9. Complete the comprehension questions on the Data Sheet.

Sample Data Sheet

Questions: Which is the manipulated variable? Which is the responding variable? On which axis (horizontal or vertical) did you plot the manipulated variable?

Table 1

Type of Object	Standard Masses (g)			Total Mass, TM
	2 g	**5 g**	**9 g**	**(g)**

Shape a piece of clay into a cube. Balance the clay cube with washers on the equal arm balance. Record the measurement on Table 2. Then mash clay into a disk. Make prediction about the mass of the clay disk. Determine the mass of the clay disk. Record the measurement. Repeat the procedure for a clay sphere.

Table 2

Shape of Clay	**Standard Masses (g)**	**Total Mass, TM**

Questions: Does the mass of the clay depend upon its shape? A mound of clay has a mass of l6 g. What would be its mass when the clay is shaped like a bar of soap? If the clay soap bar was cut in half, what would be the mass of each half?

This is just one of many experiments the students in grades 3-8 can do to determine the mass of objects. The lab work can be modified to satisfy the needs of students and teachers. For teachers who teach all subjects this activity integrates science, math, language arts, and art.

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Multiplying and Factoring Polynomials Using Algebra Tiles

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Objectives:

To eliminate the frustration and anxiety involved with Multiplying and Factoring polynomials through the usage of Algebra Tiles. Upon achieving this, accuracy in the operations will be reach.

Apparatus needed:

1) Algebra Tiles
2) Math-Tiles display board
3) A collection of students labsheets

Recommended strategy:

Math is a frightening subject to most people. I feel that it can be due to an infinite amount of reasons, but the one reason cited most is the fact that it is a precise science. Either you have the right answer or the wrong answer. Thus most individuals tend to steer clear as much as possible away from it. Having knowledge of the above mentioned fact I would start out by playing a game called "The Rectangle game." In brief, you give the students a random number of blue, red, and yellow tiles. Then give the following instructions "make the largest rectangle you can using only these tiles." In some instances you may need to add these clarifications to the directions: (1) All tiles must lie flat on the board; (2) Only one layer of tiles is allowed; and (3) the rectangle must be entirely filled in. Once they have experimented and experienced this game they are expected to develop a strategy for rapidly arranging the tiles to create the largest possible rectangle. (For us, "the largest" means largest in area.) Using this meaning, the largest rectangle will always be the one that leaves the least amount of "left-over tiles."

After the students have been stimulated by playing "The Rectangle game," I would then proceed to give the tiles names that are associated with their area. The correlation will be geometrically displayed on a poster board. Once the students have received the naming of the tiles, I would then proceed with my introduction to the multiplication of polynomials. It is extremely important that they can visually see the process of putting the factors to be multiplied on the outer vertical and horizontal space provided with the simulated Mathtiles display board given to them, and how to create the rectangle in the innermost space. It must be emphasized that the length and width are determined by the factors on the outer horizontal and vertical spaces. Also, when creating the rectangle in the innermost space, use the strategy develop with "The Rectangle game." Once you have given the students a sufficient amount of time to make the innermost rectangle, list what particular tiles were used. Show the actual problem that they did on the board making sure they understand the procedure for doing this. I would then make sure that I do a wide variety of problems to make the students analyze their results. A labsheet parallel with the topic of multiplying polynomials will then be pass out.

Having sufficiently motivated the students to get involve, I would then proceed to show the students how to factor polynomials using this truly wonderful manipulative. It's in factoring polynomials that the mathtiles will perhaps provide you with the greatest rewards. The tiles make factoring so easy that difficult problems turn into simple puzzle-type exercises. In fact, the students will see that "The Rectangle game" was actually an exercise in factoring second-degree polynomials. Hopefully, with the usage of manipulative students will in time began to understand and accept math without all of the fear that has been associated with it throughout the years.

References Material: Mathtiles Manual Book by Peter Rasmussen

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Vision Props of Signed Numbers

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Objectives:

1. By titrating with an acid and an alkaline solution, students will understand that an acid added to an alkaline can become neutralized and by adding more acid, the alkaline solution can become acid.
2. After demonstrating the titration of an acid and an alkaline solution, students will perceive that the pH factor, a measure of acidity, neutrality, or alkalinity of a liquid or a solid in relation to their own bodies.
3. Students will gain an understanding of the titration experiment by using the abstract pH factor color charts and transferring the positions to signed numbers (positive or negative numbers).
4. By using the abstract tube for their number lines, students will become aware of the importance of the number line and usage of signed numbers.

Apparatus Needed:

Two 500 ml beakers
Four 200 ml flasks
Four eyedroppers
1M of NaOH (Sodium Hydroxide)
1M of HCl (Hydrochloric acid)
One bottle of litmus paper (blue)
One bottle of litmus paper (red)
One bottle of antacid
One box of baking soda
One bottle of wide range pH 3.0 to 11.0 of phenolphthalein
Six 17cm x 21cm of acrylic glass, colors--red, orange, yellow, green, clear, and blue.
One long tube about 270 centimeters long and 6 3/4 inch in diameter
Two red plastic book covers and two blue plastic covers

Recommended Strategy:

Be prepared to encourage students to see how the phenolphthalein has the property of turning blue in NaOH (Sodium Hydroxide) and turning red in HCl (Hydrocloric acid), and adding HCl drop by drop with stirring to the sodium Hydroxide will become colorless. An alkali neutralizes of an acid to water and salt solution.

1. Pour 1M of NaOH into a 500 ml beaker, and pour 1M of HCl into a 500 ml beaker. Pour from the 500 ml beaker of NaOH into a 200 ml flask

about 100 ml, and two or three drops of the phenolphthalein into the 200 ml flask of NaOH.

2. Repeat the same for HCl.
3. Take out a blue litmus paper, drop a little of HCl from the 200 ml flask. The red color shows that hydrochloric acid is an acid. Take out a red litmus paper. Drop a little of NaOH from the 200 ml flask. The blue color shows that sodium hydroxide is an alkali.
4. Have the students to take a blue litmus paper and a red litmus paper, placed under their tongue. If the red color shows from the blue litmus paper of a pale pink color, they are somewhat acidity. if the blue color shows from the red litmus paper of a pale blue color, they are somewhat alkali.
5. Add HCl (hydrochloric acid) from the 200 ml flask where the drops of phenolphthalein was added to the solution, drop by drop with stirring to the 200 ml flask of sodium hydroxide where the few drops of phenolphthalein was added to the solution. When the sodium hydroxide becomes colorless, the reaction has neutralized. When the sodium hydroxide becomes red, the reaction is completed.
6. Pour NaOH (sodium hydroxide) from the 500 ml into another flask. Add two or three drops of phenolphthalein. Add sodium hydroxide from the flask drop by drop with stirring to the hydrochloric solution from the 200 ml flask. When the hydrochloric acid becomes colorless, the reaction has become neutralized. When the hydrochloric acid becomes blue, the reaction is completed.
7. Pour HCl from the 500 ml beaker into another flask. Add two or three drops of phenolphthalein. Add two - four teaspoons of an antacid that have aluminum hydroxide and magnesium hydroxide, both are alkali solutions, to the HCl in the flask. The hydrochloric acid becomes white, the reaction has become neutralized.
8. Pour HCl from the 500 ml beaker into another flask. Add two or three drops of phenolphthalein. Add l/2 teaspoon of baking soda (sodium bicarbonate), a source of alkali, to the HCl in the flask. The hydrochloric acid or HCl becomes a clear lime color.
9. Divorce chemistry and explain to students that the concentration of hydrogen ions in a water solution is normally a matter of importance for the hydrogen ion is responsible for all acid properties and that includes us. The concentration of hydroxide ions will be basic or alkali. In mathematical form it is pH = log 1/(H+) and pOH = log 1/(OH-). The pH is the logarithm of the reciprocal of the molar concentration of the hydrogen ion and the pOH is the hydroxide ion.
10. Take the two red plastic book covers and measure the amount needed to put inside the tube (about 6 1/4 inches wide) glue the edges with acrylic glue.
ll. Take the two blue covers and repeat the above.
12. Cut acrylic glass 17.5 x 21cm of red, orange, yellow, green, clear, and blue for a pH chart.
13. Demonstrate how to use the mathemathical approach for signed numbers using the tube. Let red represent positive numbers and

blue represent negative numbers.

l4. Place chart on chalkboard--magnetic strips can be used to hold acrylic chart. Students can select a color from the pH range to represent the continuum of signed numbers.

If more information is needed on the use of " Vision Props" of signed numbers, this author can be reached after 6:00 P.M.

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Positive and Negative Numbers

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Objectives:

Students should be able (after concrete examples are shown) to realize that zero is not the lowest number used in mathematics or real life, that there are NEGATIVE numbers and how to use them.

Materials Needed:

Acetate paper
Pointer
Screen
Light (for screen)
Various colored crayons

Strategy:

By using the number line (vertically) and the "team" method to introduce adding and theory AND a practical method of performing subtraction involving any possibility (or combination), it is hoped that students will feel at ease with negative numbers even though they will continue to prefer positive numbers and concepts in their daily life. (The number line method is familiar to math teachers; the "team" method is merely a grouping of all positive numbers together under a plus sign and doing the same to the negative numbers under a minus sign, determining which sign has the bigger total, and applying this sign to the difference of the two "teams." Subtraction will involve the teacher emphasizing it is NEGATIVE adding, using positive and negative minuends and subtrahends, demonstrating the difficulty of finding the exact differences in many cases. As a result the teacher will by example demonstrate that subtracting is negative adding by inquiring of the class if they do not see that giving a student a negative sum of money is not the same as taking that very sum away. The method of changing any subtrahend's sign to the opposite sign, and treating the result as an adding problem will give the correct answer to the subtraction problem. It will be mentioned, also, that the changing of signs should occur on the side to allow the teacher to see the original problem. Three of the four possible combinations will be done in this manner. Finally the method will be shown to work on two POSITIVE numbers, thereby recalling a simple second grade problem to reassure students that changing the method of subtraction does not violate what they have already learned.)

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Positive-Negative Charge Model For Integers

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Objective:

To represent operations on integers with positive and negative charges.

Materials:

Overhead projector, drawing of an empty beaker on an acetate, bingo chips (two colors needed).

Procedure:

The "positive-negative" model was used to represent addition and subtraction, however, this model can also be extended to represent division and multiplication.

To use this model the blue chips represent negative charges. The red chips represent positive charges. The beaker represented on the acetate will be used to combine the charges. We are not concerned with individual charges, but with collection of charges in the beaker. Therefore, an empty jar would have a collective charge of zero. If the jar contains an equal number of blue and red chips, the charge is also zero. Three positive (red) chips and three negative (blue) chips form a 1:1 correspondence and they therefore cancel each other. The collective charge of the beaker is zero.

Addition

Ex. 1. +3+(4)=+7

Place three red chips in the beaker, add four red chips. The collective charge is now a positive seven.

Ex. 2. -5+(2)=-3

Place five blue chips in the beaker then add two red chips. Match a blue and and red chip 1:1 until two sets of zeroes are matched. Remove the matched chips from the beaker. There are now three blue chips remaining in the beaker. The collective charge is now represented by as negative three. The answer -3 represented by the three blue chips.

Subtraction

Ex. 3. -2-(+7)

Place two blue chips in the beaker. We now must create +7. Add zeroes (seven red chips and seven blue chips), to the beaker. The collective charge is -2. Now, remove the seven positive (red) charges. Only blue (negative) chips remain. Your answer is represented by the nine blue chips that remain.

Multiplication and division can be similarly represented.

A COMPLETE MODEL FOR OPERATIONS ON INTEGERS by Michael Battista
Arithmetic Teacher, May 1983.

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THE SINE FUNCTION

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Objectives:

To familiarize the students with the concept of the sine function by defining, by graphing, by computer generating, by using a "shop created" blackboard sine wave generator, and by presenting examples of natural phenomena which result in sine wave motion.

Materials:

1) a plexiglass sine wave generator; 2) blackboard and chalk; 3) a computer and CRT with appropriate software; 4) a handout containing computer generated sine graphs, a table of values of the sine function from 0 to 90, a pictorial definition of the sine function, a copy from a Physics textbook of a section explaining periodic and oscillating motion.

Strategies:

In teaching this concept, I began by talking about an elementary example of a wave i.e. an ocean wave with its attendant amplitude and periodicity. I then changed models and demonstrated a sine wave on the chalkboard by using a shop-created sine wave generator. Here, I was able to be somewhat more mathematical by relating the height of any angle to movement on the Y-axis and lateral distance as movement on the X-axis. This lead to a formal mathematical definition of the sine function. Next, I graphed the function Y=sin X. I did this by using values of 90, 180, 270, & 360 degrees (quadrantal angles). Using these values, I showed that the value of the function oscillates between 1, 0, & -1. In the same context, I showed how any intermediate angle, plugged into the equation, will likewise be a point of the same graph. The values for the intermediate angles were obtained from the table of values provided in the handout.

Following this, I went to the computer. Writing an equation on the chalkboard and asking the students to predict its graph, I was able to quickly and efficiently run through several variations of the sine function without the tediousness of using the chalkboard. Incidentally, although it might be considered of marginal relevance, we did review the programming that created these graphs. Next, I discussed the phenomena of the sine wave in nature. The handout contained a copy of a section of a Physics text book dealing with oscillations and periodic movement. The significant idea here, being that this type of motion (the movement of a pendulum and the motion of a mass at the end of a spring-natural phenomena) will always be mathematically expressed in terms of sines and cosines.

Thus, my presentation was concluded. I intended to make an interdisciplinary presentation on sine waves. In this way, I hope that I have given the students a multidimensional and hopefully memorable view of the nature and meaning of the sine wave.

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Visual Structure of Postulates and Axioms in Algebraic Operations

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Objectives:

To reinforce and retain the use of axioms and postulates in various proofs and linear transformations of equations.

To have student build a physical model of the game of "PRUFF" either as a card game or as a board game.

Materials:

Approximately 40 cards listing postulates, axioms, and definitions as taken from your text book. It is a good idea to put examples of each either below or on the back of each card. Make up about 25 problem cards with current problems from your text answer should be placed on back. Try to avoid problems that require paper to solve. About 20 cards which have proofs on left hand side you show statements and the reasons are placed on the back of card.

You may use these cards either as a Card Game as they are or design a Board Game as you will find in description of game.

Strategy:

From the beginning of the semester student must place each definition, axiom, postulate, or property on a card the size of, or smaller than an index card. These cards are to be called P-Cards. Each card should have examples describing the Axiom or Postulate on the back of the card. During the sixth week or at the end of third chapter we are ready to begin playing the game. The instructor writes out ten or more proofs or solved equations giving the reasons on the back. The students separate into groups of about 2 to 6 in each. They each take 5 cards and try to find the reasons for the proof statement. If they have one they place it on the table and look for a second, If they do not have any they pick a card from their deck and the turn goes to the next person. The person with the least cards after the time allotted is the winner.

To play the Board Game "PRUFF" you make another set of cards called problem cards, these are selected from current problems in the text. Each player selects a marker and rolls the die to see who goes first. Highest roll shakes die and moves marker that number of squares. He can either land on a problem or a pruff. If it is a pruff, he looks at the top statement on the Proof Card if he has a reason he places P-card on table and looks for second reason. If he does not have p-card to fit reason he draws one from deck thus completing his turn. When one lands on problem card she selects top problem and tries to solve it. If she can she discards one p-card from hand. If it is incorrect she must take a p-card from deck.

If you are sent to Cage you must skip one turn after you roll the die you follow the alternate path. Follow path until the end. When you reach the end without any 'P'cards, You Win!!! If you have one "P" card, go to start to continue play (you do not have to take any new cards!) If you have 2 or more cards in your hand, return to start, take five additional "P" cards and continue playing until someone wins! (no cards at the end, or least cards when time is called.) Note:"The problems can be written in different degree of difficulty so that the students may be of various math levels.

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INTRODUCTION TO SOLVING EQUATIONS

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OBJECTIVE:

To arrive at an equation of the form X = [ ] in which the variable is isolated and the solution is then obvious through use of equivalent equations.

MATERIALS:

- -film cans (with appropriate weights inside and labeled)
- -balance scales (at least 2)
- -cards with equations written on them
- -handouts (equations to solve, twelve ball problem, the hundred artisans, and various others)
- -overhead projector
- -card with equal symbol and not equal symbol

STRATEGIES:

Each film can weighs approximately 5 grams so I let that be my 1. A individual film can with cover is approximately 7 grams so I filled each can with sand, nails, money, etc. to have 10 grams be a 2, 15 grams be a 3, etc. I let x = 4, y =3, z =8, w = 15 and v = 2 for my equations. You also need cans labeled 3x-2, 2y, x-1, z-2, 3x, 5y, z/2, w/3 and 2y+1.

Equations used v=v, 2+3=5, y+4=7, 6=2+x, 4-1=3, x-1<>x, x-1=3, 6=z-2, 2*3=6, 3x=12, 15=5y, 6/3=2, z/2=4, 5=w/3, 2y+1=7 and 3x-2=10.

Prior knowledge: variables and expressions, order of operations, evaluating expressions, properties of operations and inverse operations.

Discussion at beginning:

Solving equations: "The basic idea is to find out what x is. The catch is, that as soon as you do, they change it to something else!"

Equal symbol states that two expressions name exactly the same number. An equation is a number sentence which states that two expressions are equal. Therefore, an equation must have an equal symbol. We discussed a not equal to symbol and defined a variable as a symbol, usually a letter, that can represent any number. Remember when the solution of an equation is found, it must be checked. Symmetric property states that x-4=9 is the same as 9=x-4 and commutative property states that 113 + x is the same as x+ 113.

I will use the pan-balance scale to demonstrate how to solve simple equations incorporating the concepts of our properties and inverse operations. Each step is an equivalent equation that is easier to solve. Although the equation changes in the process, the solution remains the same. In your last step, the equation is so simple that it tells you the solution.

Okay, let's start with our first equation v=v. I demonstrated on a balance scale how any number equals itself. Also that if I add the same number to both sides of the balance scale, I will have an equivalent equation. Then we proved 2+3=5 on the scale. Now two equations with variables are solved and checked. Discussion of what we did should lead to the Subtraction Property of Equality which states that subtracting the same number from both sides of an equation does not change the equality. For all real nos. a, b, and c, if a=b, then a-c=b-c.

Our fourth equation 4-1=3 lead to a discussion of subtraction on the balance scale. We must break 4 down to 3+1 and then take 1 away or we can add 1 to both

sides. On the scale I showed that x-1 is not equal to x. In order to equate them I must add 1 to x-1. Therefore, I know that x-1+1=x. Our next equation x-1=3
2
uses the concept from the last equation that we must add 1 to both sides, then substitute x for x-1+1 to reach our goal x=4. Have a student volunteer to demonstrate that 6=z-2. This leads to a discussion of the Addition Property of Equality which states that adding the same number to both sides of an equation does not change the equality. For all real nos. a, b, and c, if a=b, then a+c=b+c.

On to multiplication: 2*3=6 means 2 groups of 3 or 3 groups of 2. Both of these need to be demonstrated. Therefore, 3x=12 means 3 groups of x = 12 so 3 x's need to be shown equal to 3x and then substituted for 3x can. Now take away equals and you are left with x=4. Make sure you check your answer. Have a student demonstrate the next equation. This leads to the Division Property of Equality: dividing both sides of an equation by the same nonzero number does not change the equality. For all real nos. a, b, and c, with c<>0, if a=b, then a/c=b/c.

Now for division: 6/3=2 is our first equation. If we break 6 up into 3 groups, each one will be a 2. For z/2=4, we need to show they are equal and then show that z/2 + z/2 = z but z/2 + z/2 = 4 + 4. Showing this on the scale leads to z=8. Have a student demonstrate 5=w/3. This leads to the Multiplication Property of Equality: Multiplying both sides of an equation by the same nonzero number does not change the equality. For all real nos. a, b, and c, with c<>o, if a=b, then ca=cb.

Finally we tried to solve 2y+1=7 on the scale using the concepts that we had learned in previous problems. Break 7 into 6+1, then subtract 1 from both sides; break 2y into y+y and 6 into 3+3, then take away equals to have y=3. Lastly, 3x-2=10.

Students should now be given the handouts and solve the equations using the methods learned and the scales if needed. When finished with their equations they need to try the Twelve Balls problem from the handout. This can be tried and demonstrated on the balance scale. The other problems from the handouts should be discussed in later sessions.

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ORDER OF OPERATIONS

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OBJECTIVES:

- -to use grouping symbols and the standard order of operations to simplify numerical expressions.
- -to use the order of operations to evaluate variable expressions.
- -to use the calculator and computer to solve numerical expressions.

MATERIALS:

- -computers
- -calculators(generic brand)
- -paper
- -pencils
- -chalk
- -chalkboard
- -eraser
- -banners(computer printouts)
- -handout

STRATEGIES:

A. To bring out the comparison of punctuation marks in a sentence with grouping symbols in a numerical expression (signs with the expressions Robin Lee Travis and I love computers;Slow Children Playing;Save Rags and Waste Paper.), ask if students can explain why the banners are ambiguous.

INFO
Without commas, the sentence Robin Lee Travis and I love computers, implies that two people love computers. Depending on where commas are inserted, the sentence can state that three or four people love computers.

Sample Activities:

1) ask students to simplify 10+2*3-1 to get as many different answers as they can (use calculators and computers to compare answers).
2) discuss the need for a standard order of performing operations so that there is no ambiguity about the value of such expressions.
3) discuss the steps of the standard order of operations and show how they would be used to simplify the expression above.

10+2*3-1	
10+6-1	multiplication
16-1	addition (from left to right)
15	subtraction (from left to right)

4) show how parentheses could be used to give different meanings to the same expression.

```
(10+2)x3-1      (10+2)x(3-1)
   12 x3-1         12 x 2
     36 -1           24
      35
```

INFO

In expressions with more than one operation, grouping symbols such as parentheses or division bars are often used to indicate the order in which to do the operations. These grouping symbols can change the meaning of an expression, just as commas or other punctuation marks can change the meaning of a sentence. Whenever the order of operation is not indicated by grouping symbols, there is a standard order of operations to be followed.(Do exponents, multiplication/division, addition/subtraction from left to right.)

In mathematics, more than in some other forms of written expression, ambiguity must be eliminated. Otherwise, different people may assign different meanings to the same symbols, and communication is faulty. Ambiguity is eliminated using grouping symbols and the order of operations rule.

In examples #1 and #2, the expressions do not have grouping symbols, the standard order of operations is used.

```
#1    13-4x2-3        #2   2x3^2-4
      13-4x2-3             2x3^2-4
      13- 8 -3             2x 9 -4
         5-3                18-4
          2                   14
```

In examples #3 and #4, notice that the two expressions have the same numbers and the same operations, but the results are different because of grouping symbols.(Do operations within parentheses, exponents, multiplication/division, addition or subtraction from left to right.)

```
#3   (8+5)x3          #4  8+(5x3)
     (8+5)x3              8+(5x3)
      13x3                8+15
       39                   23
```

B. To give additional practice using the correct order of operations, have students:
   1) replace the variable in each row or column to make a true equation in puzzle #1 (see handout).
   2) write the operations sign (+,-,x,/) in each row or column to make a true equation in puzzle #2 (see handout).

C. To check progress of students have them complete the Grouping Symbols-Review (see handout and below).

IV. COMMENTS/INFO.
The use of the calculator is so common to us that we tend to take

certain things for granted...only with the wide use of personal computers are we being forced to reevaluate the function, the appropriate use, and the correct method(s) of teaching students certain mathematical concepts using both machines.

3

It should be pointed out to students that people communicate with computers by using programs. Programs tell the computer what to do. However, it is not always necessary for a person to be able to write a program in order to use a computer. Programs can be written in such a way that an operator can use them by answering a series of questions that are written into the program. Nevertheless, the best way to learn what a computer can and cannot do is to learn a little about programming.

To program arithmetic calculations in BASIC, you use the following symbols:

+	addition
-	subtraction
*	multiplication
/	division
( )	parentheses
^	raised to a power(exponent)

BASIC follows the order of operations. Sample BASIC program:

```
10 PRINT 21*34+35/7
20 END
RUN
719 (answer)
```

Grouping Symbol-Review

Select each answer from the choices in parentheses. Write the answer in the blank.

1) ab means a______________b. (plus, divided by, times)

2) $\frac{a}{b}$ means a______________b. (plus, divided by, times)

3) a____________b means a is not equal to b. (=,<>,.)

4) Parentheses are an example of a ______________.(grouping symbol, value, variable)

Simplify each expression with the calculator. Translate each expression into BASIC. Use the computer to check answers.(Remember to type PRINT before the numerical expression.)

5) 7+(12-3)_____________________

6) $\frac{(18-3)}{(3+2)}$ ____________

7) (7x3)-(5x4)__________________

8) 10-(3+4)___________

9) 24- (63/(6+3))_______________

10) $\frac{36/12+6}{8-5}$____________

11) 15-5x2+8/4__________________

12) 20(12-8)-30/(10+5)___________

Simplify the expression on each side of the ----?----.
Make a true statement by replacing the ? with the symbol = or <>. Check your answers using the computer.(If the computer prints 1, your answer is true; if your answer is false, the computer will print 0.) Remember the numerical expressions must be in BASIC.

```
13) 16+3   ?   9+3 _______          14) (8-3x2)   ?   (8-3)x2_________
    ---- ----  ---                             -------
    8+4        4-1

4
15) 3(5+2)  ?  3x5+2 ______                16+4    ?   8+4x3____________
          -----                     16) 1+ ----  -----  ----
                                           3+2         8-2-2
```

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COMMUTATIVE, ASSOCIATIVE AND DISTRIBUTIVE PROPERTIES

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OBJECTIVES:

1) To compute expressions like (56 + a) + 4 and (50 * 7) * 2;
2) To identify the commutative and associative properties;
3) To rewrite expressions by using the distributive property;

MATERIALS:

1) chalk
2) blackboard
3) electroboard
4) response sheets
5) pencils

STRATEGIES:

1) Class discussion of understanding of terms commute, associate and distribute.
2) Class discussion of dictionary meaning of terms commute, associate and distribute.
3) Teacher blackboard demonstration of mathematical application of terms commutative, associative and distributive properties.
4) Teacher demonstration of electroboard.
5) Three-student-teams demonstration of electroboard.
6) Class participation with response sheets.

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It's About Time

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Objectives:

This mini-teach has been designed for first and second graders. You may alter it in any way to accommodate your grade level. The main objective is to tell time to the hour on an analog clock and how to compare more and less time.

Materials Needed:

Average size classroom of 20-25 students.

1. Analog Clocks
2. Puzzle Clocks
3. 6-Rings and 4-Cones
4. Stop Watches
5. Beads and String
6. Scissors
7. Box of Connecting Cubes
8. Box of Attri-Cubes
9. 2 Transparent Cups
10. Tape
11. Large and Small Spoons
12. Star and Square Shapes

Strategy:

Start out by asking students what time they got up this morning (answers will vary). Write times on the board, and explain each time on the hour. Pass out the analog clocks and explain the parts and their functions. Then call out a series of different times to the hour. Have students show you the correct time on their analog clocks. Ask students how long they think it will take to put together a puzzle clock. Let them give you a time. Group students in pairs, one student can use the stop watch and the other student can put the puzzle together. Record the estimated time and the actual time. Repeat the same procedure using beads and string. Have students string 30 beads then record the estimated time and actual time. To compare more and less time, have students cut out a simple shape (square) and a complex shape (star). Let them tell you which will take more or less time to cut. Record the results. Then have them fill 2 3/4 cups of water (use tape on cup for visual limitation) using a small spoon for one cup and a large spoon for the other cup. Record estimated time and actual time. Take boxes of connecting cubes and attri-cubes, and have students empty the boxes (one at a time) then replace cubes 2 at a time. Record the estimated time and the actual time. Stay in groups for ring tossing. This activity is timed at 20 seconds per student. Line-up the cones one after the other, about 8 inches apart. Let students toss the rings for points (green-6 points, blue-4 points, and yellow-2 points). When the 20 seconds is up the student with the most points should be rewarded.

Performance Assessment:

When lesson is completed ask students if they enjoyed the activities. Then let them tell you why (answers will vary). At this time students should have an understanding of time to the hour. They should be able to relate school time, lunch time, and bed time to their real life situations. In addition, they will be able to compare more and less time. Example: Putting on shoes with laces or putting on slippers. It will take more time to put on shoes with laces.

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Multiplication and Areas

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Objectives (Grades 3-5):

To learn two-digit multiplication using math facts.

To find areas of rectangles and squares.

To review addition and subtraction facts.

To be able to fill an order of items of equal and different prices and quantities.

Materials Needed:

rulers, stamps (new and/or used, singles and sheets of different denominations and sizes), magazine ads stamps (from the Ed McMahon $10,000,000 Sweepstakes), stamp order catalogues, play money (dollars and change), transparent grids and Lego platforms with different numbers of squares and dots, scissors, order forms

Strategies:

Show the students 3x4, 4x5, 6x4 square grids, or various sizes of Lego platforms and ask them to count the squares and the dots one at a time. Next, show them large size grids and Lego platforms and have them count the dots individually. Tell them to count the number of squares or dots in one row across and another row down and multiply the two numbers. Point out that it is much easier and faster to count the total by this method. Demonstrate this on the board.

Distribute 3x3, 4x3, and 4x4 sheets of stamps. Ask the students to find the total area of each sheet and then find how much each sheet costs. Ask how much would you pay if each sheet costs 4 times the face value. Have one student from each group be the stamp dealer from whom the children can buy stamps.

Pass out sheets of different denominations, sizes, and quantities. Ask the students to find the area of one stamp and then the area of the whole sheet. Next, find the total price of each sheet.

Distribute single, square stamps, preferably used, each attached to a piece of cardboard paper for easy manipulation and protection from being mutilated. Find the area of each stamp and then determine how many stamps would fit in an area of 24x24 sq. cm., 28x28 sq. cm., and 35x35 sq. cm., for example. You may want to reverse all activities to look like this one.

Here is an **example** for another activity:
Suppose you spilled some liquid on one of the sheets that you treasure very much and you are willing to pay any reasonable price to replace it. The sheet has 40 stamps of 22 cents each. The dealer asks for an extra 15 cents per stamp over the face value. Find out how much you would pay per stamp, then for the

sheet. Also calculate the profit the dealer made.

Distribute sheets of different quantities. Ask students to find the face value of each sheet by multiplying the price of one stamp by the number of stamps in the sheets. Look for current prices in the catalogues and decide how much each sheet would cost today. Next, find the area for one stamp and then for the whole sheet.

Notes: All the above activities may be used for the fifth grade for teaching division. First, ask to find the area of the whole sheet and then the area of a single stamp.

The same activities may be used to teach social studies. Ask questions about the event or person the commemorative stamp was issued for.

Performance Assessment:

Pass out the sheets of magazine ads stamps. Choose a denomination and write it down on the lower right hand of each stamp. Find the area for one stamp and then for the whole sheet. A dealer offers you 68% of the face value. Calculate your loss if you decide to sell.

Pass out copies of order forms and ask them to order as many sheets or single stamps as they want and write them in the proper columns in the form. Find out the total of the order. Add sales tax and shipping and handling charges.

Write on the board the years in which the rate of first class mail went up in one column, and the rate increase in another at random. Ask students to arrange them chronologically. Next, ask them to make a line or a bar graph to show the rate hike. Then have them calculate the percentage of the increase each time it occurred.

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Zone Out!

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Objective:

This lesson is designed for grades K-3. To review previously taught concepts of time, hours and 1/2 hours. To help children with the concept of the four different standard time zones in the 48 states.

Materials Needed:

Collect in advance the following items:

Judy clocks	paper plates	wht. paper	U.S.A. map
scissors	crayons	fasteners	black and red construction paper

Strategy:

1. Review telling time by demonstration and then let class review on their own with individual Judy clocks.
2. Make paper plate analog clocks.
3. Discuss the four standard time zones on U.S.A. map.
4. Give the students a teaser question: "My friend in New York called her grandfather in California. It was 8:00 a.m. and she woke him up! How can that be?" Discuss why they think she woke him up.
5. Let children share their own experiences with time zones; for example going to visit relatives in California and seeing a TV announcement that a show will be on at "8:00 p.m. eastern 7:00 p.m. central and 5:00 p.m. pacific time."
6. Show using map why the time zones are different. Practice with students to be sure they understand the different zones. Give them a time in the eastern time zone and get them to line up across the room in the other three time zones. Change the time and place new students in different spots to review.

Performance Assessment:

Step six of my strategy is the first way I will be able to assess my students. I can tell how much students have mastered this concept through a discussion and an individual performance evaluation.

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Elapsed Time

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Objectives:

Student will calculate elapsed time, given beginning and ending time.
Student will state the time using a.m. and/or p.m.

Materials needed:

Model demonstration clock (for teacher use)
U.S. map
Time line
Paper plates (for the third grade class)
Poster board cards (5" x 5")
Fasteners
Scissors

Strategy:

I. Teacher will introduce and discuss elapsed time using a typical school day after eliciting activities and the exact time they take place from the students between the hours of 9:00a.m. and 2:30p.m.

II. Students will individually construct an analog clock; teacher and helpers will assist.

III. Introduce the problem: Student entered a contest and has won an all expense paid trip to participate in M.C. Hammers' Annual Youth Camp held in San Antonio, Texas. However, he/she must check in at the M.C. Ranch before noon tomorrow.

IV. List things to be done before leaving and time intervals.

Shopping	begins:	2:45p.m.
Packing		7:05p.m.
Cab ride to bus station		9:00p.m.
Luxury charter bus ride from Illinois to Texas		10:15p.m.
Bus arrival time in San Antonio		9:35a.m.
Limousine arrival time at M.C. Ranch	ends:	10:30a.m.

V. Demonstrate, discuss and teach using the given problem and list of the things to be done. Use the individual time intervals for teacher demonstration and student hands-on activity showing the actual revolutions on the clocks. Elicit correct responses from the students and place on the chalkboard. Upon completion of list, students are to determine total elapsed time. Point out next day arrival.

VI. Total time and next day arrival time prompts introduction of a.m. and p.m. through the use of a time line and the scheduled activities given earlier by the students. Give meanings and relationship to day and night and to the clock. Class will determine if arrival time is a.m. or p.m. after a brief discussion.

VII. Introduce small group activity: Each student in the group will select a time being sure to indicate whether a.m. or p.m. Helpers will record given times on the sheet entitled Hours and Minutes. Each group will determine elapsed time intervals on their worksheets using their clocks and their a.m./p.m. cards. Allow one member from each group to utilize the time line as a means of verifying the time and whether it's a.m. or p.m.

VIII. Pass out worksheets entitled "Time" and also "Telling Time to the Minute" as a follow-up lesson or practice.

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Telling Time in Different Time Zone

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Objective:

To have the 4th grade students learn to tell time in different time zones.

Materials:

Paper plates, fasteners, crayons, scissors, pencils, pens, markers, 2 different colors of construction paper, digital and standard face clocks, transparency of time zone map and time zone maps for class, funtac, envelopes and card boards.

Strategy:

1. Discuss with the students the importance of knowing the time in different places so that people can communicate with each other without having time conflict.

2. Show students a standard clock

3. Have students make their own clocks out of the paper plates.

4. Show students the map of the U.S.A. that shows the various time zones. Show time zone map transparency which explains time zone divisions. Read the time on the map with students and discuss the time in different parts of the U.S.A. Give students the map of the U.S.A. that shows the various time zones.

5. Have students turn their clocks to the current time and ask students if the current time in California is the same as the time in Chicago. Wait for students to respond. Ask questions about various time zones.

6. Group students into six groups. Each group represents a different time zone (Hawaii, Alaska, Pacific, Mountain, Central, and Eastern).

7. Instruct groups to turn their clocks to a specific time in any time zone and have all groups adjust the time to their particular time zones. Then ask them if their time is behind or ahead of the specific time given. Ask questions on various time zones and have groups change zones.

8. Give each group an envelope that contains four state labels. Have the group find the states and the time zones. One of the group members places the labels on the map of the states and tells the time zone and the difference from the time in the Central time zone.

9. Give each group a card board that has two clocks on the top, one indicates the Chicago time and the other one is blank with the word Hawaii on the top. Below the clocks there are questions which ask students to look at the Chicago time and find the Hawaii time and describe what boys and girls would

be doing in both states at that time.

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Area, Arithmetic and Algebra

Larry Freeman
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Kenwood Academy
5015 South Blackstone Avenue
Chicago IL 60615
(312) 535-1409

Objectives:

To show how area of rectangles and squares can motivate the learning of multiplication rules for certain binomials, specifically:

$$(x + y)^2 = x^2 + 2xy + y^2$$

$$(x + y)(x - y) = x^2 - y^2$$

To show those teaching upper-grade math and high school first year math how their students can perform arithmetic based on these identities.

To show by paper folding several applications of the "distributive law" of multiplication over addition/subtraction.

Materials:

Cardboard demonstration set for the teacher (with magnetic tape backing) and printed sets of squares and rectangles for students to examine and re-arrange at their desks. Prepare packets of pre-cut squares and rectangles, one for each student.

Student materials should be prepared on centimeter-ruled paper; two cm = one unit. (In this fashion, area can be checked by simply counting squares). The entire square will measure 16 x 16 units, with heavy horizontal and vertical lines partitioning it into an 8 x 8, 4 x 4, and two 8 x 4 rectangles. All measurements start from the lower-left hand corner of the large square. Enter dimensions on every edge; in the interior of each rectangle should appear "Area = ______________ square units".

Two of each square will be needed for each student packet: one left whole and one cut along the heavy lines into the four rectangles. The teacher will need a similar set of materials, very much enlarged and made of heavier paper ("tagboard" is ideal). In addition, prepare a set of the four cut rectangles very much enlarged. They must be on heavier still cardboard and backed with magnetic strip material to adhere to typical metallic base chalkboards. The teacher's uncut square should be pre-folded along the heavy vertical and horizontal lines.

Strategy:

Review the area formula for a rectangle. Immediately have students remove the four small rectangles and arrange them to form a large square. How many different arrangements can they find -- rotations and reflections are "different" in this case? Sketch each arrangement in a student's notebook. Find the area of every large square by adding up areas of the four components. Encourage students to confirm this identity:

$(a + b)^2 = a^2 + 2ab + b^2$ [a = 8 and b = 4]

Challenge: Using as many of the small pieces as needed, ask students to create a rectangle whose measurements are 8 x 16. Sketch the arrangement they discovered, and, as before, try to discover and sketch as many different arrangements as possible. Calculate the total area by adding the components. The student will note that all but the small square were used in the second rectangle:

So 8 X 16 = 128 which also equals $12^2 - 4^2$ [144 - 16 = 128].

The teacher should duplicate these arrangements with the large magnetized rectangles on the chalkboard. The algebraic identity here demonstrated is:

$(x - y)(x + y) = x^2 - y^2$. [Here x = 12 and y = 4].

Second challenge: Have students take the larger square from their packet and fold it along the vertical line. The left side is now a rectangle whose measurements are 8 x 12. But it consists of two rectangles: 4 x 8 and 8 x 8. Thus they have shown that 8 X 12 = 8 X 4 + 8 X 8. So they have proved that

8 X 12 = 8(4 + 8) [an illustration of the distributive law]

Third challenge: With new teacher-made packets -- identical to the originals **except** that variable names replace numerals for dimensions. Another difference: These paper rectangles should not have centimeter ruling. Now the student should follow every step above using variables instead of numerals. The writing of the appropriate identities is left as an exercise for the teacher; answers available from the writer.

Performance Assessment:

While students are working on this project, either individually or in pairs, the teacher circulates, assesses performance visually and gives hints, commendations or other encouragements (via adroit questions). Later, notebooks themselves will be graded for completeness and accuracy. Ultimately knowledge will be "assessed" via customary pencil and paper tests. [Ruth Mitchell-type global assessment techniques do not seem cost effective for this unit.]

References and credits:

This unit was inspired by a conference table discussion with Porter Johnson. In fact none of these techniques is really new; they are frequently re-discovered in many different places at widely different times by creative teachers inspired to improve textbook versions of "the method."

Multicultural Dimensions:

Geometry is not the exclusive possession of any culture in any historical era ancient or modern. All peoples who had concerns with land and its measurement or with calendars developed appropriate geometrical principles. Similarly with arithmetic: Counting and rudimentary computing were known to all peoples, ancient or modern, no matter what geographical location. None was limited by "culture" in matters of commerce; rather our current awareness or ignorance is a function of the available historical record and its readability. It is pointless to try to ascribe primacy or originality to any cultural group.

Algebra was a European inheritance which came most directly from the Mediterranean Moorish (Muslim/Islamic) civilizations. They, in turn certainly drew from the ancient Greek, Hindu and African civilizations. Every civilization refines and improves what it inherits.

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Tony's Tiger BITES

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Objective:

Given a recipe the student will be able to make equivalent fractions, follow directions and complete the recipe.

Materials:

recipe for Tony's Tiger Bites
microwave oven
13x9x2-inch pan
4-quart mixing bowl
spatula
waxed paper if needed

Strategy:

Using the list of ingredients in the given recipe the student will calculate the amount needed to make twice the recipe, 3 times the recipe, 1/2 of the recipe and 1/4 of the recipe.

Activities:

1. review multiplication and division of fractions
2. make equivalent fractions 3x, 2x, 1/2, and 1/4 of the recipe
3. review kitchen safety rules
4. follow recipe to serve 32 Tony's Tiger Bites
5. ENJOY FINISHED PRODUCT

1 10-ounce package (about 40) regular marshmallows
1/2 cup margarine
1/3 cup peanut butter
7 1/2 cups or one 10-ounce package Kellogg's Frosted Flakes cereal

1. In a 4-quart microwavable bowl, melt marshmallows and margarine on High for 3 minutes, stirring halfway through cooking.
2. Stir in peanut butter until mixture is smooth. Add Kellogg's Frosted Flakes cereal, stirring until well coated.
3. Using a buttered spatula or waxed paper, press mixture into a lightly greased 13x9x2-inch pan. Cut into 1 1/2x2-inch bars.

Note: Use fresh marshmallows for best results.

Range-Top Method: Melt margarine in large saucepan over low heat. Add marshmallows and stir until completely melted. Remove from heat. Follow steps 2 and 3 above.

Follow up activity will be to check the nutritional value and percentage of U.S.

Recommended Daily Allowances.

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Properties of Numbers

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536-8680

Objectives:

To contrast the "mean" behavior of 0, 1, 2 and regular numbers. Numbers will be likened to students.

Apparatus Needed:

Memory
chalk board, chalk.

Recommended Strategy:

Numbers 0, 1 and 2 will be regarded as "dissident" students. 0 will act as "murderer" in multiplication, but will not even touch numbers when addition or subtraction is required. To divide by 0 creates "mission impossible". 1 does not like division and multiplication. It is invisible as a coefficient or exponent (like Dracula). 2 hides only once in radical (square root). Zero is the only lonely number. The others walk in pairs on a number line as twins. Some numbers, like square root of 2, 5, 7..., cannot be written even in one hundred years, but one knows their location on the number line.

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Make-and-Take: Staff Development

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Objectives:

1. Demonstrate some materials which can be used to provide a phenomenological approach to math
2. Show how to construct the materials

Apparatus Needed:

1. Manila file folders or paper
2. Acetate sheets for overhead projector
3. Sewing snaps
4. Paper circle
5. Handout on curves of constant width
6. Wooden model of wagon with Rouleaux triangles for wheels
7. Plastic cube
8. Colored rubber bands

Recommended Strategy:

1. Demonstrate Materials: suggest uses
2. Explain how to make demonstration models for the overhead using manila folders, acetate sheets and sewing snaps.
3. Use wooden wagon model and clear container of liquid to show that the strange looking wheels work very well
4. Fold the paper circle to create many different polygons and solid figures and to study their properties

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An Introduction To Sets

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Objective:

The student(s) will recognize the symbol for set and will demonstrate the rules of set.

Materials Needed:

A random sample of materials, some of which have a common factor (color, shape, type of material, weight - mass, or other physical property).

Procedure:

The teacher (or students) will provide individual items. The student is asked to list the characteristics, or properties of the object. He (or she) is then asked to compare his list with a fellow student's list to make a master list. This step may be repeated more than once depending on the size of the class, and the comprehension of the student(s) regarding the categorizing, or classification process. The teacher may ask for a volunteer to put his list on the board for purposes of comparison, and illustration. The teacher will then introduce the term and notation for set, and will establish the rules for inclusion or exclusion from a particular set. Following a demonstration, new materials (or objects) will be introduced and used by the student to test his (or her) understanding. Abstract symbols are now introduced with further demonstration and testing by teacher and student.

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Discovering New Units

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Objective:

With frequent work with Cuisenaire Rods the students will develop a systematic usage for creating new units or in finding a common denominator, in use with the skills for adding and subtracting unlike denominators.

Apparatus needed:

A set of Cuisenaire rods for each student or groups of two.

Recommended strategy:

Before students can develop a system for determining common denominators, a Hierarchy of Skills must be accomplished. The student must develop an understanding of basic concepts metacognitively. The goal is to use our entire mathematical schema. The desired sequence is:

1. they must know the meaning of addition and subtraction
2. they must master all basic concepts (addition, subtraction, multiplication and division)
3. they must understand common fractions as related to physical models (fraction strips, shapes divided into parts, number lines)
4. they must be familiar with prime and composite numbers (use of a Hundreds chart is helpful)
5. they should be able to add and subtract common fractions or like denominators

Children upon completion of these skills can develop the knowledge that equivalent fractions will yield a common denominator.

Children can be led to discover the relationship between numerical values of the rods and multiples that can be derived, thus leading them to the goal of developing new units not included in rods, i.e., 12, 15, 18, 21, etc.

Activities:

Review common fractions in everyday use. (Show each fraction with your rods.) 1. What fractional part is a stick of butter to a whole package? (After each question students will display the appropriate fraction with any color combination.) 2. I have six eggs. What fractional part of the carton do I have? 3. In a mixture of equal portions, we need 1 part Hydrogen and 1 part Chloride. What is the fraction to name each part? 4. Marci's father was asked to design a playroom for 3 and 4 year olds. The room needs areas for play-rest-music-and lunch. The room should be divided into how many equal parts? Write the fraction; show the fraction. What color rods did you use to show each fraction above? Did everyone use the same colors each time? (No.) This begins the development of alternative color combinations.

With work children can be led to include their knowledge of multiples of the set of counting numbers, as well as their multiplication facts or tables of factors (2x3=6; 5x2=10; 3x3=9, etc.).

To add fractions with uncommon denominators such as 1/3 + 5/6 our denominators need to contain the same unit. My unit needs to be at least 6 lengths long. Ask for a relationship between the numbers 3 and 6. Children can readily equate 3x2=6. Display a dark green rod, make a train of white rods as long as the dark green unit rod. How many white rods did you use? What color rod is 1/3 of dark green? Red, yes. How many red rods did you use? Show one red rod and five white rods. What is the answer? You can't tell immediately because we need to change everything to one color before we can combine the two, so we now need to trade our red rod in for how many white rods? (2). Now we can add them together. What is your answer? (7/6 is correct, write on board). We call 7/6 an improper fraction because the numerator is greater than the denominator, therefore we need to trade up now, I'm trading six white rods in for one dark green rod. What fraction is left? Students can easily see the answer to this question as 1/6 and the answer to the problem as a mixed number of 1 1/6.

Conclusion:

Problems of this nature can be explored by the teacher with the student's furthering their understanding of the idea of trading up and down to find common denominators. This same procedure should be followed with mixed numbers for adding or subtracting. Children should be given the opportunity to develop their own strategies for finding a common denominator. A list of 5 to 10 problems with unlike denominators can now be placed on the board for their further investigation with the teacher giving aid wherever necessary.

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PLAY BALL

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OBJECTIVES:

1) Given the White Sox averages, compute the batting averages and earned run averages.
2) Given general dimensions of the playing field and some equipment, change to the metric system.
3) To find the diagonal distance from 3rd base to 1st base.
4) To find the diagonal distance from 40 ft behind 3rd base to 1st base.

MATERIALS:

1) overhead projector
2) prepared transparencies
3) White Sox average sheet from the Chicago Sun-Times (7-16-86)
4) picture of a baseball field
5) blackboard
6) baseball
7) bat
8) calculators
9) an official baseball rules handbook

STRATEGIES:

Does anyone know the nation's oldest active major league ballpark?

Comiskey Park

Fine-----Let's Play Ball

The league President appoints an official statistician to maintain an accumulative record of all the batting, fielding, running, and pitch-ing records for each player. This morning we are going to complete an abbreviated average table. This table was obtained from Wednesday's Sun-Times--July 16, 1986. (Figure 2)

Batting averages = **Hits** / A.B. The percentage of times that a player gets a hit.

The headings for each column will be explained. The formula will be emphasized and the students will now compute the batting averages of the names listed on their table.

Earned Run Averages = (ER/IP)9 The average number of runs a pitcher allows his opponents to score.

The headings for each column will be explained. The formula will be emphasized and the students will now compute the earned run averages.

Certain dimensions are given of the playing field and equipment. (Figure 3) Change standard units to the metric system.

Using the baseball field: Find the distance from 3rd base to 1st.

Draw the distance. Compute.

Pythagorean Theorem OR 45-45-90 Rt Triangle

$d^2 = 90^2 + 90^2$ Leg times the sq rt of 2

d = 127.28 ft. d = 127.28 ft.

The left fielder catches a bouncing ball 40 ft. behind the 3rd base. How far would the out-fielder have to throw the ball. Draw the distance. Compute

Pythagorean Theorem

$d^2 = 130^2 + 90^2$

d = 158.11 ft.

BRAINTEASER

There are 100 seats available at the baseball game. These seats may be divided in proportion to men, women, and children. However, the cost of the tickets for these seats must equal exactly $100. The cost for a man is $5.00, for a woman $2.00, and for a child $.10. Determine the number of men's, women's, and children's ticket to purchase.

(Figure 2) WHITE SOX AVERAGES (Completed)

Batter	AVG	G	AB	R	H	2B	3B	HR	RBI	GW RBI	SAC	SB	E
Baines	.316	84	332	50	105	18	2	12	53	6	7	1	2
Hairston	.308	54	107	16	33	7	0	2	18	3	1	0	0
Bonilla	.262	71	221	26	58	9	2	2	25	1	3	4	2
Cruz	.261	49	134	28	35	1	0	0	15	1	1	5	4
Walker	.261	62	222	29	58	10	6	10	43	5	2	1	5
Hulett	.258	74	233	26	60	11	5	6	21	3	5	2	7
Guillen	.252	83	278	34	70	11	3	2	33	5	4	6	11
Cangelosi	.243	80	272	47	66	11	2	1	17	2	5	39	4
Tolleson	.236	71	233	36	55	6	3	3	23	2	12	13	8
Lyons (S)	.233	9	30	4	7	0	0	0	2	0	0	2	0
Lyons (T)	.247	69	154	24	38	7	2	1	16	1	0	3	3
Fisk	.216	76	287	30	62	8	0	7	45	4	6	2	7
Kittle	.208	75	259	29	54	10	0	13	41	2	6	2	0
Skinner	.186	52	129	13	24	3	1	2	4	1	1	1	3
Nichols	.182	40	55	3	10	2	0	0	7	3	0	5	0
Others	.200	--	85	11	17	1	0	0	2	0	0	0	12
Totals	.248	86							360	36	55	83	65
Opponents	.258	86							378	40	54	58	68

Pitcher	W	L	ERA	G	GS	CG	SH	SV	IP	H	ER	BB	SO
Dawley	0	4	2.77	27	0	0	0	1	48.2	45	15	15	33
Bannister	5	5	3.17	12	11	0	0	0	65.1	64	22	23	31
McKeon	3	1	3.04	28	0	0	0	1	26.2	14	9	17	13

(figure 3) General Dimensions

Multiply by		Standard	Round to	Metric
.09290 Divide by 10000	Playing Field	2 acres ($87120\ ft^2$)	Nearest tenth	.8 H
.3048	Diamond	90 ft	" "	27.4 m
2.54	Baseball	9 to 9.25in	Whole no to tenth	23/23.5 cm

28.349523	Baseball (wt)	5 0z	" "	142 g
3 "	"	5.25 Oz	" "	149 g
25.4	Bat (diameter)	2.75 in	" "	69 mm
.3018	Bat	42 in	Nearest hundredth	1.07 m
2.54	Batter's Box	17 in	Whole no	43 cm

(Note: Figure 1 is a picture of the baseball field which is attached to the end of this report.)

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USING VARIABLES AND RATIOS TO GET YOU IN THE RIGHT GEAR

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OBJECTIVES:

1) To apply the concepts of variable and ratio in everyday situations. 2) To determine the gear ratios and gears for a 12-speed bicycle. 3) To write a computer program which will determine gears using the bubble sort technique

MATERIALS:

1) Overhead projector and transparency sheets
2) Blackboard and colored chalk
3) Erasable laminated memo pads
4) 12-speed bicycle and bicycle mount
5) Handout explaining gear ratio

STRATEGY AND PROCEDURE:

The session will begin with a brief review of the hierarchy of arithmetic operations. Students will first give examples of various hierarchies (army, gov't, school,...). To remember the order of operations the students will use the mnemonic device PEDS (Parentheses, Exponents, Division/ Multiplication, Subtraction/Addition).

The overhead projector will then be used to show the students a short program in PSEUDO-BASIC. They will use the hierarchy to determine the output of this program. The program will motivate a discussion of the concept of a variable. The laminated pad will be used to see how once a value for a variable is replaced , that value forever disappears. The program is as follows:

```
 10  READ X
 20  Y=3+4*X-2
 30  PRINT X,Y
 40  IF X<>0 THEN 20
 99  END
110  DATA   4,-2,3,0
```

Two practical examples of ratios will then be given. The first will be a baseball player's hits per at-bats. The second the # of records sold per records sent at Honky-Tonk Hick Records in Marengo. For both variable and ratio I want the examples to motivate definitions from the students.

We will then turn to an application of variables and ratios. A student will mount a 12-speed bicycle in front of class and try to determine the various gears by shifting and judging the tension. The rest of the students will determine the gears by using:

$$\text{gear ratio} = \frac{\text{\# of teeth on chainwheel}}{\text{\# of teeth on freewheel}}$$

This will be abbreviated using the variables g=c/f. Two diagrams of the chainwheel, freewheel, and their relationship will be drawn on the board: one to show the gears as determined by the student on the bicycle, and the second to be used by the other students who determined the gear ratios. The lower the gear

ratio, the lower the gear. A handout will be distributed clarifying these concepts.
2

The results of the cyclist will then be compared with that of the students who computed the gears mathematically. Any differences which may appear will be discussed and accounted for (cyclist error in judging tension, old chain which has stretched, wear on chainwheel and freewheel, etc). Finally, a computer program will be distributed which determines gear ratios and gears using the bubble-sort technique.

DEFINITIONS: **variable**- a symbol (usually letter) used to represent an unknown #

ratio- a quotient a/b comparing two elements, where b<>0

bubble sort- a programming technique where data is stored from "lowest" to "highest" or vice-versa

PSEUDO-BASIC- a simplified version of BASIC for students not familiar with programming languages

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Amarillo Texas

We watched the LP -(Low Precipitation) supercell for about 40 minutes as it came at us. Video section has a clip of this storm, showing the rotation and development as it came towards us.

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Amarillo Texas

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Sturgeon Bay Wisconsin

One of the nicest places I have been. No storms to chase, but the scenery from N Wisonsin is awesome. This was shot about 530 am, at the main Marina downtown

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Alamosa Colorado

Nice rain shaft W of Alamosa, Colorado. The E edge of the Rocky Mountains is nearby, so it was fairly flat here

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Beggs Ok

One of the best looking wall clouds I have seen, that DID NOT produce a tornado

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Meade Kansas

This is the back side of the 5.27.01 Derecho in W Kansas and Oklahoma. When it hit us S of Meade Ks, the winds were 112 mph. When THIS storm hit Oklahoma City three hrs later, the wind speeds were still 94 mph. Check the Video Section for what it's like to be hit by 112 mph Derecho winds.

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Okfuskee Ok

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Liberal Kansas

Bored...waiting for storms to develop in our area

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Springfield Illinois

Shelf cloud with severe storm over Springfield , Il. About 10am, looking NW

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Cordell Ok

Earlier in the day, this storm produced a small tornado near Cordell

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Muskogee Ok

Mammatus clouds after tornadic storms earlier.

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Chickasha Ok

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Woodward Ok

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Tulsa Ok

A few cumulus towers at sunrise, after a long night of severe weather.

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Sand Springs Ok

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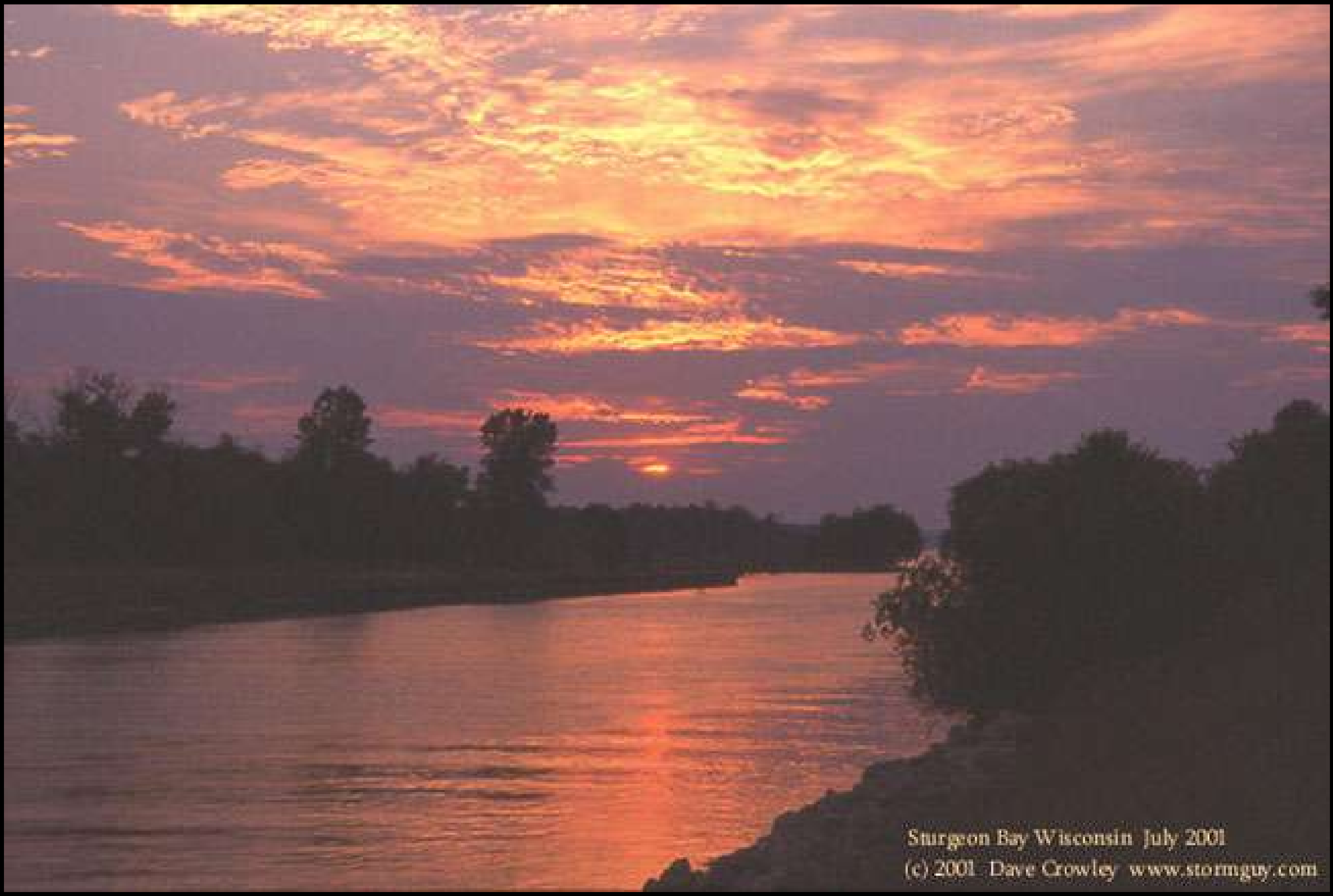
Sturgeon Bay Wisconsin



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St Louis Missouri

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Stratford Ok

Outflow dominant storm. Still looks cool though.

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Dodge City Kansas

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Dodge City Kansas

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Amarillo Texas

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Okfuskee Ok

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Beggs Ok

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Clouds & Scenics *Page 2*

Dave 'Stormguy' Crowley

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  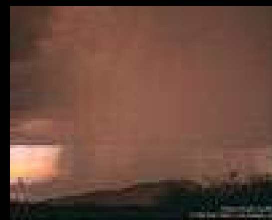 

   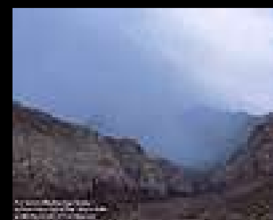

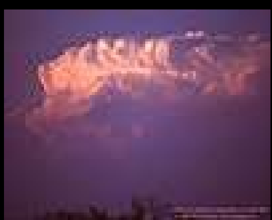  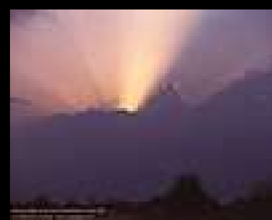 

   

 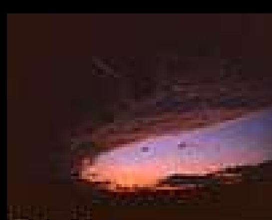  

  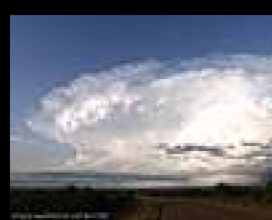 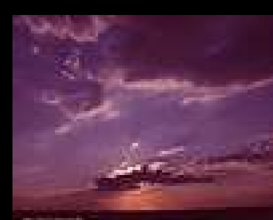

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Clouds & Scenics *Page 3*

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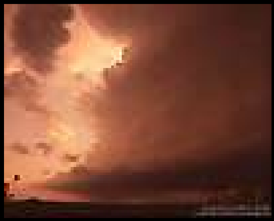 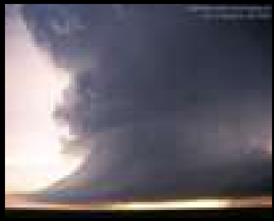  

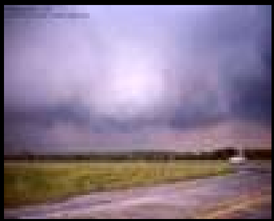   

  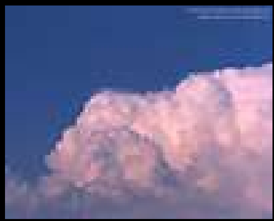 

  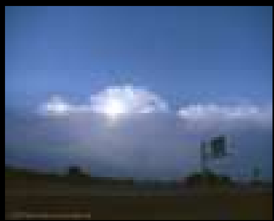 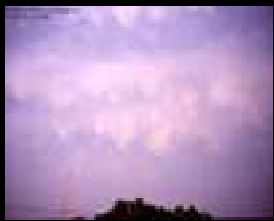

   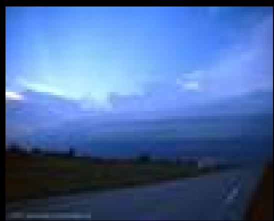

 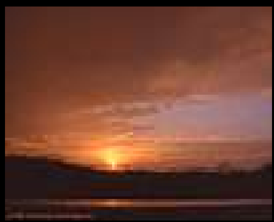  

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Clouds & Scenics *Page 4*

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These images are not linked yet..stay tuned

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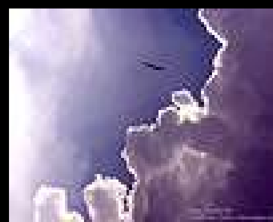


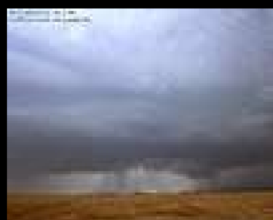




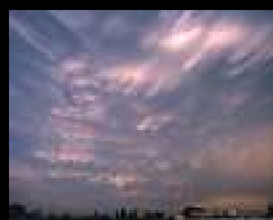
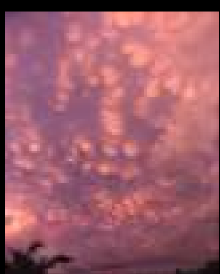



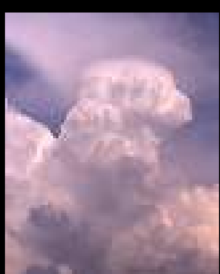
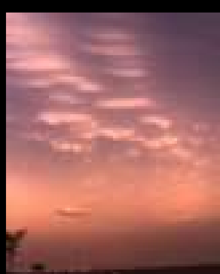

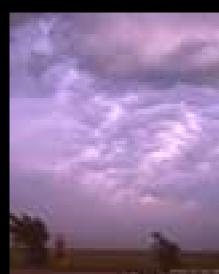

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   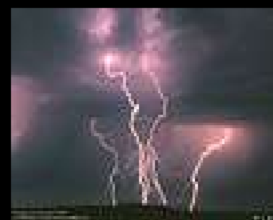

  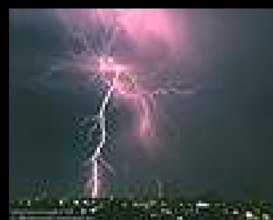 

   

   

   

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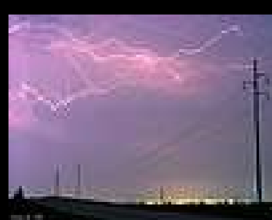
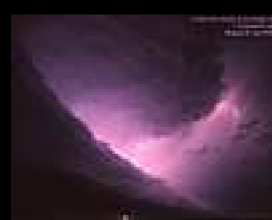






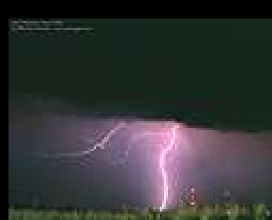
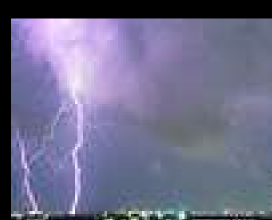


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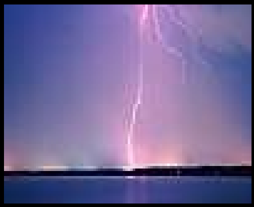











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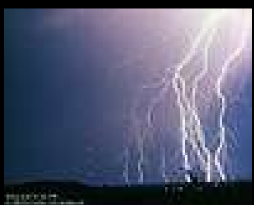













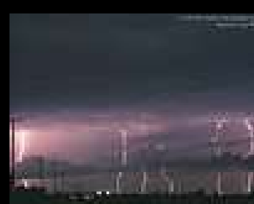

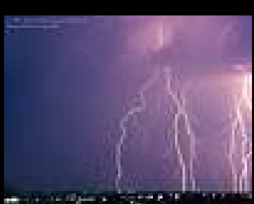


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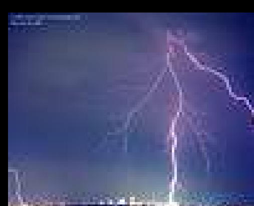





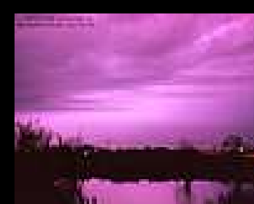



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1 2 3 4 5 6 7 8 9 10

My First Lightning Picture

My first attempt at lightning photography. I didn't have a tri-pod or cable for the camera, so I was balancing the camera on the roof of my car. This explains the reflection, and the horizon being zigzagged.

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Tulsa Ok

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Broken Arrow Ok

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Bristow Ok

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Cleveland Ok

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Clifton Arizona

South of Clifton Arizona - August of 2001. I lucked out and found this overlook down into the valley, with the storms training just to my East, rain shafts evident to the right of bolt.

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Broken Arrow Ok

Earlier this evening, (Sep 20, 2000) I was nearly struck by a bolt that hit about 100 ft behind me. After I left the hospital, this storm popped up near my home, so of course, I had to stop and try for photos. This looks to be hitting the house, with the green glow coming from the windows. Home was vacant, so no appliances to explode, just outlets to channel the voltage. No visible damage to exterior of home the next day.

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Clifton, Arizona

One bolt is hitting the mountainside. Trees in the foreground block a little of the shot, but this location was one of the most absolute darkest places I have ever done lightning photos. I was lucky the shots were straight, and had any horizon at all, since I couldn't see anything at all to set the shot up.

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Caney Kansas

Yes, this was THAT close. 50-100 ft most likely. Hard to see the bolt itself due to over-exposure. We left right after this blast.

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Catoosa Ok

One of my best images

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Tulsa Ok

Shot by my dad in 1983 from his high-rise apartment in Tulsa. Only night he ever tried lightning photography.

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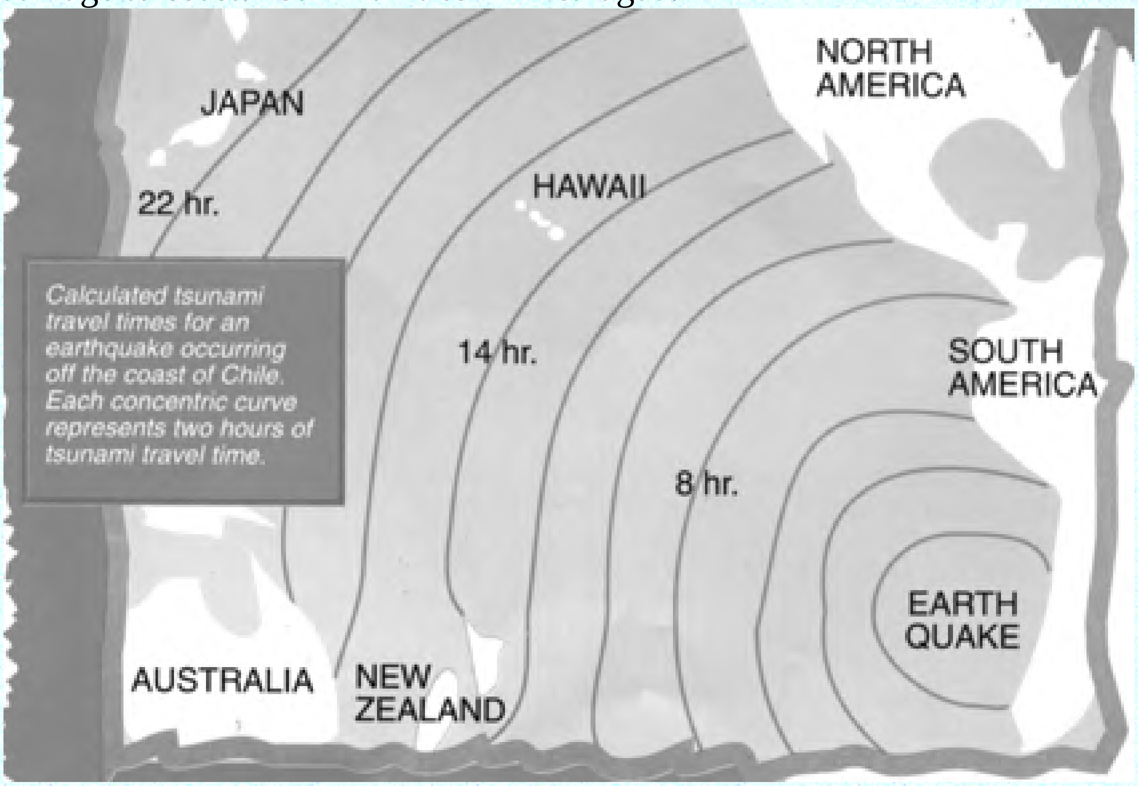
What Cause Tsunamis?

Tsunamis, also called seismic sea waves or, incorrectly, tidal waves, generally are caused by earthquakes, less commonly by submarine landslides, infrequently by submarine volcanic eruptions and very rarely by a large meteorite impact in the ocean. Submarine volcanic eruptions have the potential to produce truly awesome tsunami waves. The Great Krakatau Volcanic Eruption of 1883 generated giant waves reaching heights of 125 feet above sea-level, killing thousands of people and wiping out numerous coastal villages.

The 1992 Nicaragua tsunami may have been the result of a "slow" earthquake comprised of very long-period movement occurring beneath the sea floor. This earthquake generated a devastating tsunami with localized damage to coastal communities in Nicaragua.



Not all earthquakes generate tsunamis. To generate tsunamis, earthquakes must occur underneath or near the ocean, be large and create movements in the sea floor. All oceanic regions of the world can experience tsunamis, but in the Pacific Ocean there is a much more frequent occurrence of large, destructive tsunamis because of the many large earthquakes along the margins of the Pacific Ocean.

Ring of Fire

About two-thirds of the earth is covered by the waters of the four oceans. The Pacific Ocean is the world's largest, covering more than one third of the total surface area of our planet. The Pacific Ocean is surrounded by a series of mountain chains, deep ocean trenches and island arcs, sometimes called a "ring of fire." The great size of the Pacific Ocean and the large earthquakes associated with the "ring of fire" combine to produce deadly tsunamis.

In less than a day, these tsunamis can travel from one side of the Pacific to the other. However, people living near areas where large earthquakes occur may find that the tsunami waves will reach their shores within minutes of the earthquake. For these reasons, the tsunami threat to many areas (Alaska, the Philippines, Japan or the U.S. West Coast) can be immediate (for tsunamis from nearby earthquakes taking only a few minutes to reach coastal areas) or less urgent (for tsunamis from distant earthquakes taking from 3 to 22 hours to reach coastal areas).

Earth and Earthquakes

The continents and sea floor that cover the earth's surface are part of a world-wide system of plates that are in motion. These motions are very slow, only an inch or two per year. Earthquakes occur where the edges of plates run into one another. Such edges are called fault lines or faults. Sometimes the forces along faults can build-up over long periods of time so that when the rocks finally break an earthquake occurs. Examples of features produced by forces released along plate edge faults are the Andes Mountains in South America (on land) and the Aleutian Trench near Alaska (under water). When powerful, rapid faulting occurs underneath or near the ocean, a large earthquake is produced and, possibly, a tsunami.

The deep ocean trenches off the coasts of Alaska, the Kuril Islands, Russia,, and South America are well known for their violent underwater earthquakes and as the source area for destructive Pacific-wide tsunamis.

The tsunami generating process is more complicated than a sudden push against the column of ocean water. The earthquake's magnitude and depth, water depth in the region of tsunami generation, the amount of vertical motion of the sea floor, the velocity of such motion, whether there is coincident slumping of sediments and the efficiency with which energy is transferred from the earth's crust to ocean water are all part of the generation mechanism.

Return to Tsunami, The Great Wave

Tsunamis on the Move

Wave Height and Water Depth

In the open ocean a tsunami is less than a few feet high at the surface, but its wave height increases rapidly in shallow water. Tsunamis wave energy extends from the surface to the bottom in the deepest waters. As the tsunami attacks the coastline, the wave energy is compressed into a much shorter distance creating destructive, live-threatening waves.

In the deep ocean, destructive tsunamis can be small--often only a few feet or less in height--and cannot be seen nor can they be felt by ships. But, as the tsunami reaches shallower coastal waters, wave height can increase rapidly. Sometimes, coastal waters are drawn out into the ocean just before the tsunami strikes. When this occurs, more shoreline may be exposed than even at the lowest tide. This major withdrawal of the sea should be taken as a warning of the tsunami waves that will follow.

Pacific-Wide and Local Tsunamis

The last large tsunami that caused widespread death and destruction throughout the Pacific was generated by an earthquake located off the coast of Chile in 1960. It caused loss of life and property damage not only along the Chile coast but in Hawaii and as far away as Japan. The Great Alaskan Earthquake of 1964 produced deadly tsunami waves in Alaska, Oregon and California.

In July 1993, a tsunami generated in the Sea of Japan killed over 120 peoples in Japan. Damage also occurred in Korea and Russia but not in other countries since the tsunami wave energy was confined within the Sea of Japan. The 1993 Sea of Japan tsunami is known as a "local event" since its impact was confined to the nearby regional area in the proximity of the earthquake that generated the tsunami. For people living along the northwestern coast of Japan, the tsunami waves followed the earthquake within a few minutes.

Local tsunamis also occurred in Nicaragua (1992), Indonesia (1992, 1994) and the Philippines (1994) killing thousands of people. Scientific studies indicate that local tsunamis generated off the northern California, Oregon and Washington coast can arrive within five to 30 minutes after the earthquake is felt.

How Fast?

Where the ocean is over 20,000 feet deep, unnoticed tsunami waves can travel at the speed of a commercial jet plane, nearly 600 miles per hour. They can move from one side of the Pacific Ocean to the other in less than a day. This great speed makes it important to be aware of the tsunami as soon as it is generated. Scientists can predict when a tsunami will arrive since the speed of the waves varies with the square root of the water depth. Tsunamis travel much slower in shallower coastal waters where their wave heights begin to increase dramatically.

How Big?

Offshore and coastal features can determine the size and impact of tsunami waves. Reefs, bays, entrances to rivers, undersea features and the slop of the beach all help to modify the tsunami as it attacks the coastline. When the tsunami reaches the coast and moves inland, the water level can rise many feet. In extreme cases, water level has risen to more than 50 feet for tsunamis of distant origin and over 100 feet for tsunami waves generated near the earthquake's epicenter. The first wave may not be the largest in the series of waves. One coastal community may see no damaging wave activity while in another community destructive waves can be large and violent. The flooding can extend inland by 1000 feet or more, covering large expanses of land with water and debris.

How Frequent?

Since scientists cannot predict when earthquakes will occur, they cannot determine exactly when a tsunami will be generated. However, by looking at past historical tsunamis, scientists know where tsunamis are most likely to be generated. Past tsunami height measurements are useful in predicting future tsunami impact and flooding limits at specific coastal locations and communities. Historical tsunami research may prove helpful in analyzing the frequency of occurrence of tsunamis and their relationship to large earthquakes.

Return to Tsunami, The Great Wave

Tsunami Warning Centers

As part of an international cooperative effort to save lives and protect property, the National Oceanic & Atmospheric Administration's (NOAA) National Weather Service operates two tsunami warning centers. The Alaska Tsunami Warning Center (ATWC) in Palmer, Alaska, serves as the regional Tsunami Warning Center for Alaska, British Columbia, Washington, Oregon and California.

The Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, serves as the regional Tsunami Warning Center for Hawaii and as a national/international warning center for tsunamis that pose a Pacific-wide threat. This international warning effort became a formal arrangement in 1965 when PTWC assumed the international warning responsibilities of the Pacific Tsunami Warning System (PTWS). The PTWS is comprised of 26 international Member States that are organized as the International Coordination Group for the Tsunami Warning System in the Pacific. Many Member States countries operate national tsunami warning centers, providing warning services for their local area.

The objective of the PTWS is to detect, locate and determine the magnitude of potentially tsunamigenic earthquakes occurring in the Pacific Basin or its immediate margins. Earthquake information is provided by seismic stations operated by PTWC, ATWC, the U.S. Geological Survey's National Earthquake Information Center and international sources. If the location and magnitude of an earthquake meet the known criteria for generation of a tsunami, a tsunami warning is issued to warn of an imminent tsunami hazard.

The warning includes predicted tsunami arrival times at selected coastal communities within the geographic area defined by the maximum distance the tsunami could travel in a few hours. A tsunami watch with additional predicted tsunami arrival times is issued for a geographic area defined by the distance the tsunami could travel in a subsequent time period.

Seismic and Water Level Stations of the Pacific Tsunami Warning System

If a significant tsunami is detected by sea-level monitoring instrumentation, the tsunami warning is extended to the entire Pacific Basin. Sea-level (or tidal) information is provided by NOAA's National Ocean Service, PTWC, ATWC, university monitoring networks and the other participating nations of the PTWS. The International Tsunami Information Center, part of the Intergovernmental Oceanographic Commission, monitors and evaluates the performance and effectiveness of the Pacific Tsunami Warning System. This effort encourages the most effective data collection, data analysis, tsunami impact assessment and warning dissemination to all TWS participants.

Tsunami watches, warning, and information bulletins are disseminated to appropriate emergency officials and the general public by a variety of communication methods.

Return to Tsunami, The Great Wave

Warning Dissemination Research Activities

Warning Dissemination

- Tsunami watch, warning and information bulletins issued by PTWC and ATWC are disseminated to local, state, national and international users as well as the media. These users, in turn, disseminate the tsunami information to the public, generally over commercial radio and television channels.
- The NOAA Weather Radio system, based on a large number of VHF transmitter sites, provides direct broadcast of tsunami information to the public.
- The U.S. Coast Guard also broadcasts urgent marine warnings and related tsunami information to coastal users equipped with medium frequency (MF) and very high frequency (VHF) marine radios.
- Local authorities and emergency managers are responsible for formulating and executing evacuation plans for areas under a tsunami warning. The public should stay-tuned to the local media for evacuation orders should tsunami warning be issued. And, the public should NOT RETURN to low lying areas until the tsunami threat has passed and the "all clear" is announced by the local authorities.

Tsunami Research Activities

With the broad availability of relatively inexpensive yet powerful computers and desk-top workstations, there is growing interest and activity in tsunami research. Using the latest in computer technology, scientists are able to numerically model tsunami generation, open ocean propagation and coastal runup. Recent advances in the technology have led to improved propagation and runup models.

Sub-surface pressure sensors, able to measure tsunamis in the open ocean, are providing important data on the propagation of tsunamis in deep water. Unfortunately, the mechanism of tsunami generation is not well understood.

Seismologists, studying the dynamics of earthquakes, are formulating new methods to analyze earthquake motion and the amount of energy released. Where the traditional Richter (surface wave) magnitude of earthquakes is not accurate above 7.5, the seismic moment is designed to better define the amount of energy released and the potential for tsunami generation. It is hoped that this relationship between seismic moment and the potential for tsunami generation can be refined so that the near-real time analysis of earthquakes can be performed for tsunami warning purposes.

Tsunami inundation models, defining the extent of coastal flooding, are an integral aspect of tsunami hazard and preparedness planning. Using worst case inundation scenarios, these models are critical to defining evacuation zones and routes so that coastal communities can be evacuated quickly when a tsunami warning has been issued. NOAA's Pacific Marine Environmental Laboratory is taking a lead role in developing tsunami inundation maps for coastal communities in Alaska, California, Hawaii, Oregon and Washington states.

In the area of improved tsunami wave detection instrumentation, recording systems comprised of sub-surface pressure sensors have been tested over the last decade off the Alaska and Oregon coasts. These pressure sensors, located on the sea floor, have successfully measured tsunami wave amplitudes in the open ocean. The final step in developing a deep water tsunami wave detection system for warning purposes brings together the collection of the pressure data and its subsequent rapid, reliable telemetry to the shore-based warning center. Open ocean tsunami wave detection systems using satellite or radio telemetry are being tested off the California coast.

Return to Tsunami, The Great Wave

What You Should Do

The Facts

- Tsunamis that strike coastal location in the Pacific Ocean Basin are most always caused by earthquakes. These earthquakes might occur far away or near where you live.
- Some tsunamis can be very large. In coastal areas their height can be as great as 30 feet or more (100 feet in extreme cases), and they can move inland several hundred feet.
- All low lying coastal areas can be struck by tsunamis.
- A tsunami consists of a series of waves. Often the first wave may not be the largest. The danger from a tsunami can last for several hours after the arrival of the first wave.
- Tsunamis can move faster than a person can run.
- Sometimes a tsunami causes the water near shore to recede, exposing the ocean floor. The force of some tsunamis is enormous. Large rocks weighing several tons along with boats and other debris can be moved inland hundreds of feet by the tsunami wave activity. Homes and other buildings are destroyed. All this material and water move with great force and can kill or injure people.
- Tsunamis can occur at any time, day or night.
- Tsunamis can travel up rivers and streams that lead to the ocean.

What You Should Do

Be aware of tsunami facts. This knowledge could save your life! Share this knowledge with your relatives and friends. It could save their lives!

- If you are in school and you hear there is a tsunami warning, you should follow the advice of teachers and other school personnel.
- If you are at home and hear there is a tsunami warning, you should make sure you entire family is aware of the warning. Your family should evacuate your house if you live in a tsunami evacuation. Move in an orderly, calm and safe manner to the evacuation site or to any safe place outside your evacuation zone. Follow the advice of local emergency and law enforcement authorities.
- If you are at the beach or near the ocean and you feel the earth shake, move immediately to

higher ground. DO NOT wait for a tsunami warning to be announced. Stay away from rivers and streams that lead to the ocean as you would stay away from the beach and ocean if there is a tsunami. A regional tsunami from a local earthquake could strike some areas before a tsunami warning could be announced.

- Tsunamis generated in distant locations will generally give people enough time to move to higher ground. For locally generated tsunamis, where you might feel the ground shake, you may only have a few minutes to move to higher ground.
- High, multi-story, reinforced concrete hotels are located in many low-lying coastal areas. The upper floors of these hotels can provide a safe place to find refuge should there be a tsunami warning and you cannot move quickly inland to higher ground. Local Civil Defense procedures may, however, not allow this type of evacuation in your area. Homes and small buildings located in low lying coastal areas are not designed to withstand tsunami impacts. Do not stay in these structures should there be a tsunami warning.
- Offshore reefs and shallow areas may help break the force of tsunami waves, but large and dangerous waves can still be threat to coastal residents in these areas. Staying away fro all low-lying coastal areas is the safest advice when there is a tsunami warning.

If You Are on a Boat or Ship

- Since tsunami wave activity is imperceptible in the open ocean, do not return to port if you are at sea and a tsunami warning has been issued for your area. Tsunamis can cause rapid changes in water level and unpredictable dangerous currents in harbors and ports.
- If there is time to move your boat or ship from port to deep water (after you know a tsunami warning has been issued), you should weigh the following considerations:
    - Most large harbors and ports are under the control of a harbor authority and/or a vessel traffic system. These authorities direct operations during periods of increased readiness (should a tsunami be expected), including the forced movement of vessels if deemed necessary. Keep in contact with the authorities should a forced movement of vessels be directed.
    - Smaller ports may not be under the control of a harbor authority. If you are aware there is a tsunami warning and you have time to move your vessel to deep water, then you may want to do so in an orderly manner, in consideration of other vessels. Owners of small boats may find it safest to leave their boat at the pier and physically move to higher ground, particularly in the event of a locally generated tsunami. Concurrent severe weather conditions (rough seas outside of safe harbor) could present a greater hazardous situation to small boats, so physically moving yourself to higher ground may be the only option.
    - Damaging wave activity and unpredictable currents can effect harbors for a period of time following the initial tsunami impact on the coast. Contact the harbor authority before returning to port making sure to verify that conditions in the harbor are safe for navigation and berthing.

As dangerous as tsunamis are, they do not happen very often. You should not let this natural hazard diminish your enjoyment of the beach and ocean. But, if you think a tsunami may be coming, the ground shakes under your feet or you hear there is a warning, tell your relatives and friends, and ***move quickly to higher ground***.

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Publications

You can download most publications from this page or order up to 300 free copies of most publications from your Local NWS Office, the NOAA Outreach Unit, or American Red Cross. You need a free copy of Abobe reader to view PDF files.

- **(B)**: Publications available in braille
- **(N)**: Negatives for loan from NWS Headquarters

NOAA PA#	Publication
Aviation	
93056 (N)	A Pilot's Guide to Aviation Weather Services
96052 (N)	Key to TAF and METAR Report
96076 (N)	Automated Surface Observing System(ASOS) Guide For Pilots
Boating/Marine	
94058 (N)	Safe Boating Weather Tips
98053 (N)	Mariner's Guide to Marine Weather Services Great Lakes
98054 (N)	Mariner's Guide to Marine Weather Services Coastal, Offshore and High Seas, Text only version
NA	Marine Service Charts
Children	
NEW 200451	Owlie Skywarn: Watch Out...Storms Ahead: Full Booklet in PDF
	Owlie Skywarn: Tornadoes
	Owlie Skywarn: Hurricane
	Owlie Skywarn: Floods
	Owlie Skywarn: Lightning
	Owlie Skywarn: Winter Storms
Dust Storm	
82002	Dust Storm Driving Safety (Wallet Card)
Emergency Preparedness	
20053	StormReady, StormReady Info in HTML
92054	FEMA's Emergency Preparedness Materials Catalog
NA	Red Cross: Talking About Disaster: Guide for Standard Messages
Floods	
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200253	Floods . . . The Awesome Power!, pdf
20052	Hurricane Flooding: A Deadly Inland Danger
92059	Red Cross: Are you ready for a flood or flash flood? htm or pdf
92060	Red Cross: Are You Ready for a Flood or a Flash Flood? (Spanish)

92062	Red Cross Poster: Are You Ready for a Flood or a Flash Flood? (E/S)
94059	River and Flood Program (Hydrologic Services Program)
96074E	The Hidden Danger: Low Water Crossing (English) pdf
96074S	The Hidden Danger: Low Water Crossing (Spanish) pdf

Heat

85001	Heat Wave: pdf, Heat Wave: text only
94052	Red Cross: Are You Ready for a Heat Wave?
94056	Red Cross: Are You Ready for a Heat Wave? (Spanish)

Hurricanes

70027	Survival in a Hurricane
85002	Hawaiian Hurricane Safety Measures, Central Pacific Tracking Chart
85006	Como Sobrevivir En Un Huracan (Survival in a Hurricane)
91001	Hurricane! A Familiarization Booklet: pdf
94050 (N)	Hurricanes...Unleashing Nature's Fury: pdf
94053	Red Cross: Are You Ready for a Hurricane?
94054	Red Cross: Are You Ready for a Hurricane? (Spanish)
94055	Red Cross: Are You Ready for a Hurricane? Poster (Eng/Sp)
96071 (N)	Red Cross: Atlantic Hurricane Tracking Map: pdf
96073 (N)	Pacific Hurricane Tracking Map (12 x 24")
NA	Atlantic Hurricane Names: 2003-2008 in pdf or text only
NA	Pacific Hurricane Names: 2003-2008 in pdf or text only

Natural hazard

86001 (N)	Natural Hazard Watch Warning Poster
86001	Estado De Alerta Y Estado De Peligro En Los Casos De Riesgos Naturales

NOAA Weather Radio (NWR)

200352	NOAA Weather Radio Poster
200356	NOAA Weather Radio Brochure
94061 (N)	NOAA Weather Radio pamphlet (replaces 76015)
96053	NWR Decal
96070 (N)	NOAA Weather Radio....the voice of the National Weather Service Text, pdf color
NA	Saving Lives with an All Hazards Warning Network

NOAA/NWS

92501	NOAA Brochure
93059	A Change in the National Weather Service
96051 (N/B)	National Centers for Environmental Prediction

Thunderstorms, Lightning, and Tornadoes

99050 (N/B)	Thunderstorms, Tornadoes, Lightning...Nature's Most Violent Storms: pdf or text only
200252	Fact About Lightning, pdf color
85005	Tornado Safety Tips (Como Protegerse En Caso De Tornado)(WC)
92052 (N/B)	Tornadoes...Nature's Most Violent Storms Text , pdf color
92053 (N)	Thunderstorms and Lightning...The Underrated Killers! pdf color (See 99050 for text version.)

92057	Red Cross: Are you ready for a tornado? htm or pdf
92058	Red Cross: Are You Ready for a Tornado? (Spanish)
92061	Red Cross Poster: Are You Ready for a Tornado? (English/Spanish)
93051	Red Cross: Are You Ready for a Thunderstorm?
93052	Red Cross: Are You Ready for a Thunderstorm? (Spanish)
93053	Red Cross: Are You Ready for a Thunderstorm?(Poster: Eng/Sp)

Tsunami

NA	Tsunami the Great Waves

Weather Spotters

92051 (N)	SKYWARN Decal
81011	Spotter's Guide for Identifying and Reporting Severe Local Storms
92055	Advanced Spotter's Field Guide: color PDF (3 mg FTP), text only
93060 (N)	Spotter ID Card (replaces 84001)
97050 (N)	Basic Spotter's Field Guide: full color pdf version

Winter Storms

200160 (N/B)	Winter Storms...The Deceptive Killers
91003	Red Cross: Are You Ready for a Winter Storm?
91004	Red Cross: Are You Ready for a Winter Storm? (Spanish)
91005	Red Cross Poster: Are You Ready for a Winter Storm? (Eng/Sp)

Other information regarding disaster preparedness and education can be found on the Red Cross Community Disaster Education page.

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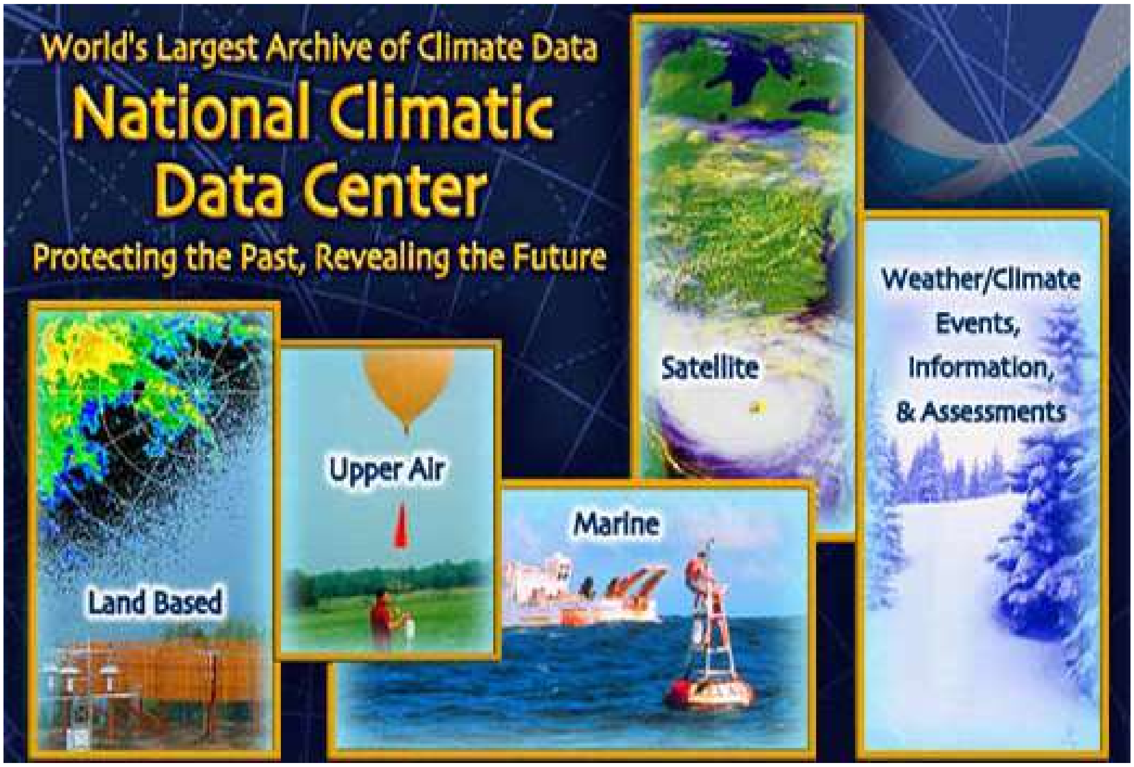

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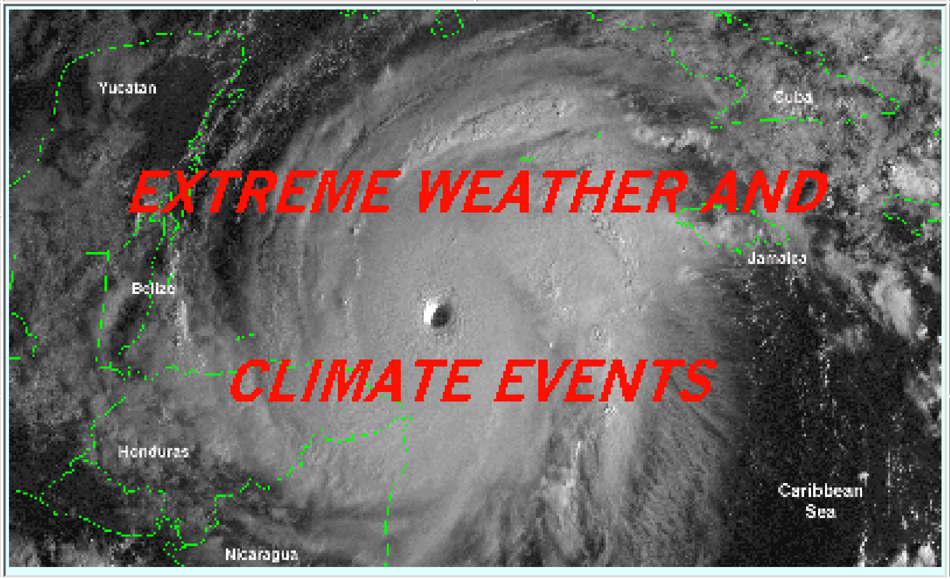
Billion $$ Weather Disasters			**Worldwide Weather and Climate Events**
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El Nino/ La Nina			**Satellite Images**
Climate Monitoring	**U.S. Local Storm Reports**	**Climatic Data**	**U.S. Radar Composites**

NCDC / *Climate Resources* / *Get/View Data* / ***Extremes*** / *Search* / *Help*

Last Updated Thursday, 01-Jul-2004 10:49:06 EDT by Neal.Lott@noaa.gov, Tom.Ross@noaa.gov
Please see the NCDC Contact Page if you have questions or comments.

To Search Web Pages:

Search for: [ ] Search!

Results per page: 20 Output format: Long Match: All

Product Catalog: [ ] Continue

Enter keyword or string to search for:

OR View List of

NCDC's Most Popular Products

Web Climate Services: (WebCliServ) **Locate a Weather Observation Station**
Search NCDC Datasets

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

National Climatic Data Center

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Current Events

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Data & Products

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- Data Access tools
- CD-ROM Products
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- Search
- Help

Purchase

- Most Popular
- Subscriptions /
- Renewals
- Order Status
- Online Store

Climate Info.

- Research
- Monitoring
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Help

and Answers to

Frequently Asked Questions

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- Subscriptions (FAQ's)
- Free Access
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Welcome to NCDC's Help Page

Please hover your mouse pointer over the links to the upper left, or simply scroll down the page to view the help topic that interests you. Should you have something specific to look for, submit a search in the golden search bar above. Email the NCDC Webmaster should you have problems using this page.

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Online Orders?

1. **I can't get to the the 'checkout' page. What's wrong?**
2. **How do I get back to the online data I ordered?**
3. **When I try to get back to my data I get a 'page not found' error. What is wrong?**
4. **I haven't received the data I ordered online. Will it be delivered in the mail?**
5. **The data I ordered is not complete. Will the data be updated?**
6. **The data I ordered is just a bunch of numbers. What's wrong?**
7. **I can't view the publication I ordered. What's wrong?**
8. **How do I print the data?**
9. **The data I received is not what I wanted. How do I get a credit?**
10. **How do I get a receipt for my online order?**

11. How do I order certified copies of the data contained in my online order?

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1. **I can't get to the the 'checkout' page. What's wrong?**
This is most likely a firewall issue on your end. You will need to have your system administrator remove the restrictions from port 443.

To explain further: On the Internet, port often refers to a number that is part of a URL, appearing after a colon (:) right after the domain name. Every service on an Internet server listens on a particular port number on that server. Typically, the nonsecure server instance is on port 80, which is the default port for http:// connections; and the secure server instance is on port 443, which is the default port for https:// connections. The 's' in the https://prefix identifies it as SSL, port 443, unless otherwise noted. Since these port numbers are the standard defaults, the port number does not need to be displayed within the URL. For more information on the Secure Socket Layer (SSL) technology see the **Security Issues** section.

2. **How do I get back to the online data I ordered?**
The URL for an online order's **Online Data Retrieval** page is presented on the Order Receipt page when the order is originally placed and again provided in the confirmation email. If you did not 'Bookmark'/'Add to Favorites' the Online Data Retrieval Page for your order and do not have the confirmation email, you can use the **Check Order Status** feature to have this link emailed to you again. When the Order Status page is returned to your screen, click on
EMAIL ME MY ORDER URL
The email is sent to the email address that was specified when the order was placed.

3. **When I try to get back to my data I get a 'page not found' error. What is wrong?**
Several things could be causing the problem. If you are trying to return to the Online Data Retrieval page and are typing the url into your browser, it is most likely a typing error. We strongly recommend you copy and paste the url from the confirmation email. This avoids any typing mistakes. Once you have the Online Data Retrieval page on your screen, we also suggest you 'Add to Favorites'/'Bookmark' this page for future reference.

If you have ordered a PDF file or a Digital ASCII product, these files are deleted from our server after 11 days. IF it has been more than 11 days and you click on a link to your data, you will get an error such as 'page not found'.

If neither of these appear to be the problem, please email nndc.weborder@noaa.gov or call Customer Service at **828-271-4800, ext 3100** for further assistance.

4. **I haven't received the data I ordered online. Will it be delivered in the mail?**
If you have your order number, you may check the status of your order on the Order Status page. If you ordered data to be delivered online, the data was delivered online as soon as the order was submitted to NCDC. After clicking on
Click Here to Submit Order to NNDC
an Online Order Receipt page was returned to the screen with the following statement:
**** YOUR ONLINE DATAFILE ORDER IS READY. PLEASE CLICK HERE ****
(https://ols.nndc.noaa.gov/olstorehtml/2094124307070011310.html)

The URL (web address) provided is the location of the Online Data Retrieval page for the order. This is the page with the links to the data. You may follow the steps for How do I get back to the online data I ordered? to get to the data. If you ordered ASCII data from the Climate Data Online system or PDF files (publications), these data are only available for 11 days after purchase. After 11 days, the files are deleted from our server.

5. **The data I ordered is not complete. Will the data be updated?**
If you ordered one of the **Form Generated Products** (Unedited Local Climatological Data, Surface

Weather Observations, COOP/Record of Climatological Observations, or Annual Climatological Summary) your access will always allow you to see the latest data available. The database is updated 3 times a week. Your access to the data is not removed. You should check back regularly for the most recent updates.

If you ordered **ASCII Data Files** (Surface Summary of the Day-TD3200/3210, Surface Data, Monthly U.S.-TD3220, Precipitation Data, Hourly - TD3240, Precipitation Data, or 15-Minute -TD3260, Surface Data, Monthly Global - TD 3500), a **View Inventory** link is provided after making the station/element/date selection and PRIOR to submitting the order. This is provided to assist the user in deciding if the order should be placed should any of the requested data not be available. For more information on ASCII files see the help for **Digital ASCII Files**.

6. **The data I ordered is just a bunch of numbers. What's wrong?**

   You have most likely ordered a Digital product. These data are delivered in an ASCII text file. For more information on ASCII files see the help for **Digital ASCII Files**.

7. **I can't view the publication I ordered. What's wrong?**

   Publications are provided in PDF (Portable Document Format) and you will need to have downloaded and installed Adobe's free Acrobat Reader software in order to view/download the publication. When you click on the link the Adobe software will open and the publication will open within Adobe if your PC has the file association created between .pdf files and Adobe Reader software. If you get an error message, either you have the wrong version of Adobe (must be 4.0 or higher) or the file association does not exist. You can right-click on the link, use 'save as'/'save target as' from the shortcut menu and save the file to disk. Open the Adobe software, then open the file from where it was saved.

8. **How do I print the data I ordered?**

   If you are printing one of the **Form Generated Products** (Unedited Local Climatological Data, Surface Weather Observations, COOP/Record of Climatological Observations, or Annual Climatological Summary) make sure your printer is set to print landscape. Then use the File, Print option from your browsers menu bar. Digital data provided in an ASCII file format is best suited for downloading into a database or importing into a spreadsheet application. If you must print the data, import into a spreadsheet application and print from there. For more information on ASCII files see the help for **Digital ASCII Files**.

9. **The data I received is not what I wanted. How do I get a credit?**

   As stated on the Order Summary page presented prior to submitting an order:

   "NOTE! You have ordered Online data, which means that you will be able to access a link to your datafiles soon after your order is placed.
   Please take note of the link to these datafiles on the Order Receipt screen.
   It is NNDC policy to NOT provide refunds for online data ordered via the Online Store.

   Exceptions to this policy are made in certain cases such as errors in processing of the order, missing data, etc. If you feel the problem with your order justifies a credit, please email nndc.weborder@noaa.gov or call Customer Service at **828-271-4800, ext 3100**. Please have your order number and the exact nature of the problem. If a valid problem exists, the order will be voided and a credit issued to the credit card.

10. **How do I get a receipt for my online order?**

    An Online Order Receipt page is presented on the screen once your order is submitted and processed through the online store. If you did not print this page for your records, you can regenerate the page by clicking on the "Regenrate my web order receipt page" button on your Online Data Retrieval page. If you do not have your online data retrieval page marked, see How do I get back to the online data I ordered?

    The NCDC DOES NOT keep paper copies of receipts for online orders.

11. **How do I order certified copies of the data contained in my online order?**

Certified copies of the Unedited Surface Weather Observations, Unedited Local Climatological Data, Edited Local Climatological Data-Online, COOP/Record of Climatological Observations, and the NCEP Weather Charts are now available through the online store. You must first purchase one of these products through the online store. On the Online Data Retrieval page for the order, click on

Order Certified Copies of Data Contained in this Order

A new order will be created - you will only be charged the certification fee for the new order. For more information and instructions, refer to the ONLINE ORDERING OF CERTIFIED DATA!!! portion of the Ordering NCDC Data & Products web page.

Subscriptions

1. **How do I access my subscription?**
2. **I have forgotten my username and password. How can I find out what it is?**
3. **How do I renew my existing online subscription?**
4. **I would like an online subscription but do not have a credit card. Is there another option?**
5. **I subscribed to the wrong product. How can I change it to the correct one?**
6. **I already receive a subscription in the mail. May I access this data online also?**
7. **I can't open any of the .gz files. What do I need to do?**

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1. **How do I access my subscription?**

   Subscription access is allowed through the Subscription Login page. You must have a user name and password to access the subscription data.

2. **I have forgotten my username and password. How can I find out what it is?**

   If you have forgotten your UserId/Password combination, please access our USERID/PASSWORD lookup system. If you wish to change your Password (User ID's can NOT be changed) or are still experiencing problems, please call our Customer Service Branch at **(828) 271-4800, ext 3100** Monday-Friday 8:00-4:00 EST.

3. **How do I renew my existing online subscription?**

   To renew an existing online subscription you will need to purchase the product(s)/site(s) again through the main Subscription Page in the online store. There is a link to this page in the Subscription Notification email and on the 'List of Stations Subscribed to-' page each time you access your subscription. You may renew a subscription at any time. If the same email address is used as was used on the original subscription, you will **NOT** be asked to enter a user name/password combination. The system will automatically add one year to the existing subscription's expiration date.

4. **I would like an online subscription but do not have a credit card. Is there another option?**

   We prefer that you purchase your subscription by using our Online Store and pay by either VISA, Master Card, American Express or Discover. If none of these options is available, we will accept a check or money order for the purchase of an online subscription product only. There are two separate subscription order forms, the Form Data Subscription Order Form (PDF) is to be used when ordering either the Unedited Local Climatological Data, Coop Data/Record of Climatological Observations, Surface Weather Observations, or Annual Climatological Data Summary subscriptions. The Edited Local Climatological Data Subscription form (PDF) is to be used when ordering the Edited Local Climatological Data publication subscription. Either form must be completed and included with your payment. Failure to enter the required fields on the form or to include the form with your payment will result in processing delays. Please mail to:

   National Climatic Data Center
   151 Patton Avenue
   Customer Services Branch

Asheville, North Carolina 28802

5. **I subscribed to the wrong product/site. How can I change it to the correct one?**

   If you wish to change your subscription product/site you must contact Customer Service at **828-271-4800, ext 3100**.

6. **I already receive a subscription in the mail. May I access this data online also?**

   The offline subscription is a completely separate item from the online subscription access. If the dollar amount remaining in the current mailed subscription is sufficient, it may be changed to the online access. The correct Subscription Access Form must be completed and sent to the NCDC. Please contact the subscription department at **828-271-4800, ext 3169** for more information.

7. **I can't open any of the .gz files. What do I need to do?**

   To save the files, simply right-click on the filename, choose Save As/Save Target As from the shortcut menu and save to disk. You can then uncompress these files using WinZip (Microsoft Windows/NT environment) or standard UNIX gunzip/tar. After uncompressing these files, you will be able to read these into a spreadsheet such as Microsoft Excel (specify delimited by comma) or any standard database application. See the Downloading or Uncompressing Files help for more information.

Free Access

Free access to NNDC and NCDC data is granted to certain users. Please read the revised **Online Data Access Policy** to see if you may be one of these users.

Free Access is granted using reverse domain lookup. If the domain of the PC being used resolves back to our system as a designated free user you will be allowed access into the data files. Your network administrator will need to verify that the PC being used to access our system resolves to a domain name and not just an IP address. A **Listing of REMOTE Environment variables** script can be run from your browser and the output from this will indicate the REMOTE_ADDR (ip address) and REMOTE_HOST (domain name) for the PC. The "remote_host" address will tell exactly how the PC or workstation being used is "seen" from the outside and by NCDC. For example, if your email address ends in .edu, but "remote_host" says something else, your domain is not resolving to .edu. Show this to your system administrator, who should then be able to correct the problem on your end.

*** IMPORTANT ACCESS INFORMATION ***
There are two types of data that can be accessed free for certain users: Publications and 'Form Generated' products.

PUBLICATIONS: The publications must be accessed through the **NCDC Document Library**. To access these you can click on the title of the publication. If your domain resolves correctly access will be allowed.
FORM GENERATED PRODUCTS: Access to the data products **Unedited Local Climatological Data**, **COOP/Record of Climatological Observations**, **Surface Weather Observations**, **Annual Climatological Summary**, and the digital ASCII files from the **Climate Data Online System (CDO)** is granted through the online store. Although access is through the store, if the domain resolves correctly you should never see this button:

Add to Shopping Cart

Instead, you will be provided links to access the data you have selected.

Digital ASCII Files

Orders placed through the Climate Data Online system for any of the digital products such as Surface Summary of the Day-TD3200/3210, Surface Data, Monthly U.S.-TD3220, Precipitation Data, Hourly - TD3240, Precipitation Data, or 15-Minute -TD3260, Surface Data, Monthly Global - TD 3500 are delivered as **ASCII Data Files**. **You will need to download these files as soon as possible. They are deleted from our server after 11 days.**

The Online Data Retrieval page for these orders presents two links for each product: (please note the links below are only samples to aid in the help process):

Links to Form Data are Below:
Your Climate Data Online file CDO00115917 will be available at http://www5.ncdc.noaa.gov/prod/cdohtml/CDO341888428.html

The **CDO00115917** link provides a Request Summary:

Selected Meteorological Element(s): 'PRCP'	**Date Range** (Year / Month): 1999/01 to 2000/04
	Selected Output Format: Comma Delimited, without station name
	Selected Output Media: FTP
	Total Data Rows Available: 16 - View Inventory
	Output File Size (bytes): 9576
	Price: $10.00

The **http://www5.ncdc.noaa.gov/prod/cdohtml/CDO341888428.html** link is the data access page:

File Contents	Access URL	File Size (bytes)
SOD - Surface Data, Daily - US & some non-US	http://ftp.ncdc.noaa.gov/pub/upload/795257568dat.txt	9576
SOD - Surface Data, Daily - US & some non-US - inventory	http://ftp.ncdc.noaa.gov/pub/upload/617309570inv.txt	355
Station List	http://ftp.ncdc.noaa.gov/pub/upload/305084229stn.txt	503
SOD - Surface Data, Daily - US & some non-US format documentation	http://www5.ncdc.noaa.gov/cdo/soddoc.txt	

The 1st link (...dat.txt) is the data.
The 2nd link (...inv.txt) is the inventory.
The 3rd link (...stn.txt) is the station list.
The 4th link (...doc.txt) is the documentation.
Please note that most digital dataset documentaion is also available here.

The documentation is very important for interpreting the data file. Users of these data usually download the data into an existing database or spreadsheet application. There are both documentation and data samples available to the user from the point a particular digital dataset is selected. These are available throughout the pages in the on-line store. Once the station(s)/element(s) are selected, an inventory is provided showing what is available based on those selections. This is provided to assist the customer in deciding if the order should be placed should any of the requested data not be available. The Dataset Documentation is also available in several places throughout the on-line store and here. The documentation describes the placement of the elements within the file and also describes the allowed values and codes. For more information please visit the HELP page for the NCDC Climate Data Online system.

SPECIAL NOTE: If you receive a **"Server not Responding"** error after choosing the station(s) and period of record, it is probably due to slow query time to build the inventory page. You should limit the selection of stations, period of record, or elements until able to get to the next page and the browser does not time out. Some queries for a large chunk of data may take an hour or more to process. Files are only provided if the compressed size is <40 megabytes. if the filesize is > 5 megabytes, then the file is compressed using tar and gzip. You may download the file by right-clicking on the filename, 'save as' to your local machine. After downloading the file, unzip the file by using either WinZip in a windows environment or using gunzip/tar in a unix environment. See the Downloading or Uncompressing Files help for more information.

Security Issues

1. **I'm not sure about putting my credit card on the web. How secure is your site?**
2. **Your site wants to set a 'cookie' on my machine. What is this?**

---

1. **I'm not sure about putting my credit card on the web. How secure is your site?**

   The online store is very secure and we have hundreds of users placing orders every day. The Checkout page and subsequent pages from the online store are sent using a Verisign Digital Id which incorporates **Secure Sockets Layer (SSL) technology**, which is the industry-standard protocol for secure, Web-based communications. This basically means that all pages from the Checkout page onward in the Online Store are sent encrypted across the internet so that if the data, as it travels from point to point, is viewed, it would be unreadable. The SSL technology is the algorithm that encrypts the data and the 'trust' that we are NCDC to you, the customer, as you transmit your credit card. The encrypted credit card data when it arrives to us on our web server is ONLY unencrypted by that server and cannot be unencrypted by any other machine in the world! To further explain this visit the Verisign web site.

2. **Your site wants to set a 'cookie' on my machine. What is this?**

   A "cookie" is a small amount of information that a web site copies to your hard disk. Cookies are used extensively throughout most web sites (especially e-business sites) for relating shopping cart entries to specific machines. Since the web is a stateless entity, we need a method to track items that may be added to an individual's shopping cart. Cookies are the method that is used to accomplish this. The cookie that NNDC and NCDC set consists of a random number that identifies only the machine, **not any personal information about the individual**. The cookies set by NNDC & NCDC are deleted immediately after the items are purchased or within 10 days which ever is less. No historical database is maintained. You can find an explanation of cookies and their intent at the Cookies 101 web site. If you wish to order data through the online store at the discounted price, your PC must be set to accept cookies. Otherwise, you may contact NCDC for other ordering options.

Downloading or Uncompressing Files?

Some of our files are large and require that we compress them to save our disk space and your time in transferring them to your site. Because of this fact, you will need special software to uncompress these files. This softwareis public domain software and you may download it to your PC or Workstation free of charge.

It is impossible to document the usage and syntax of all of these utilites, however, several of these do have a link to a document explaining their usage and syntax in detail.

Further questions about compressing/uncompressing files may be addressed to ncdc.webmaster@noaa.gov.

Additional links that may be useful:
System Help and Detailed Information - Receipt and Usage of Data
Utility Software links

Finding Data, Information, and Assistance

Data/Products by Category/Type--Our developing page to narrow your search
Most Popular Products--A categorized listing of products
Select Data by State, County, City, etc--Our Climate Data Online (CDO) system for full period of record weather data
System Help--Our NNDC system help page
Utility Software--Our new software links page, for viewers, browsers, 'decompressors', etc
Climatic Data--Our central page for all online climate data and images
Satellite Data--Our central page for all online satellite data and images
Radar Data--Our central page for all online radar data and images
Inventories, Station Lists--Pertaining to online and off-line data
Publications--Online and off-line publications and reports
Extremes, Events, Climate Change, El Nino/La Nina, Etc

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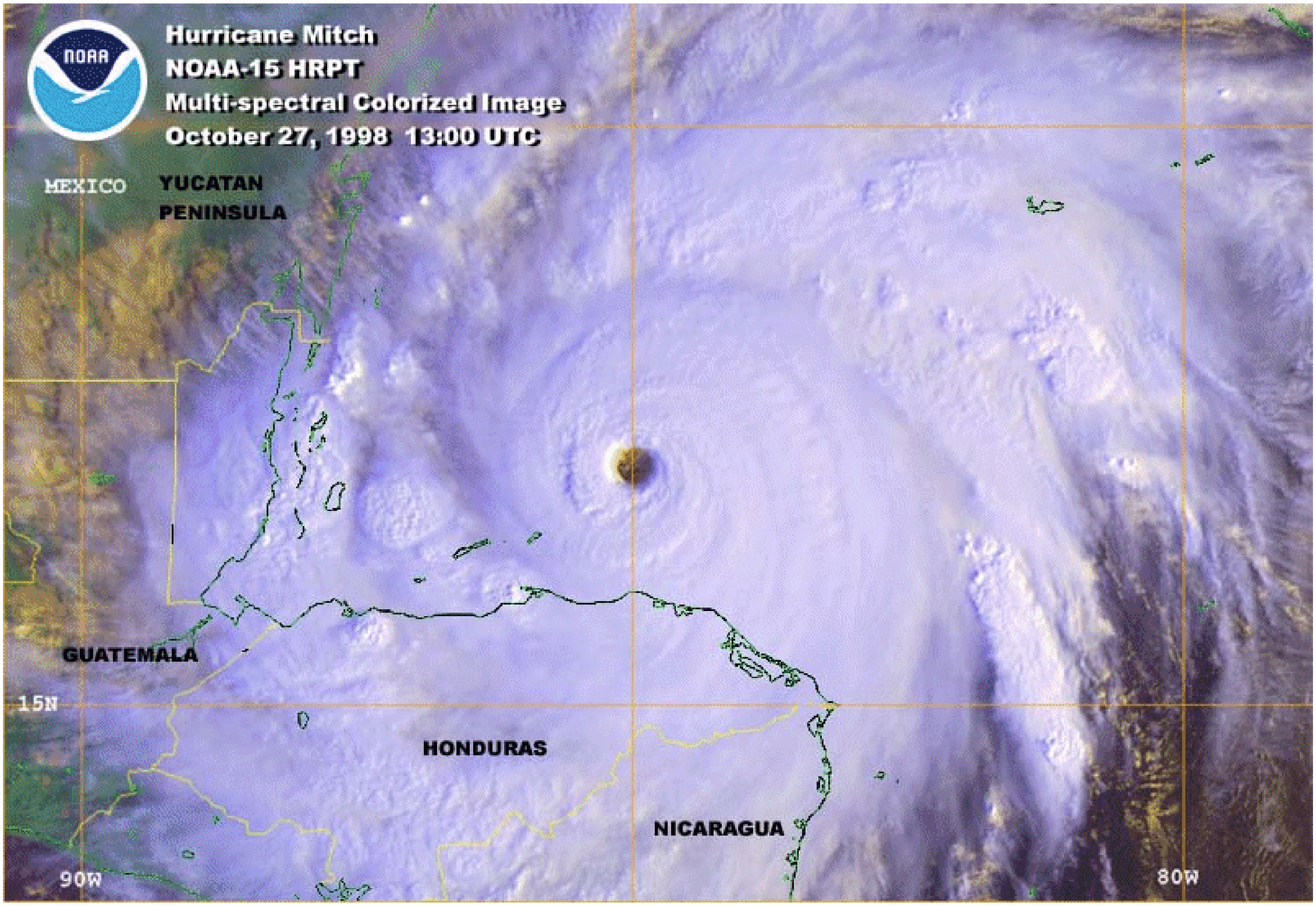
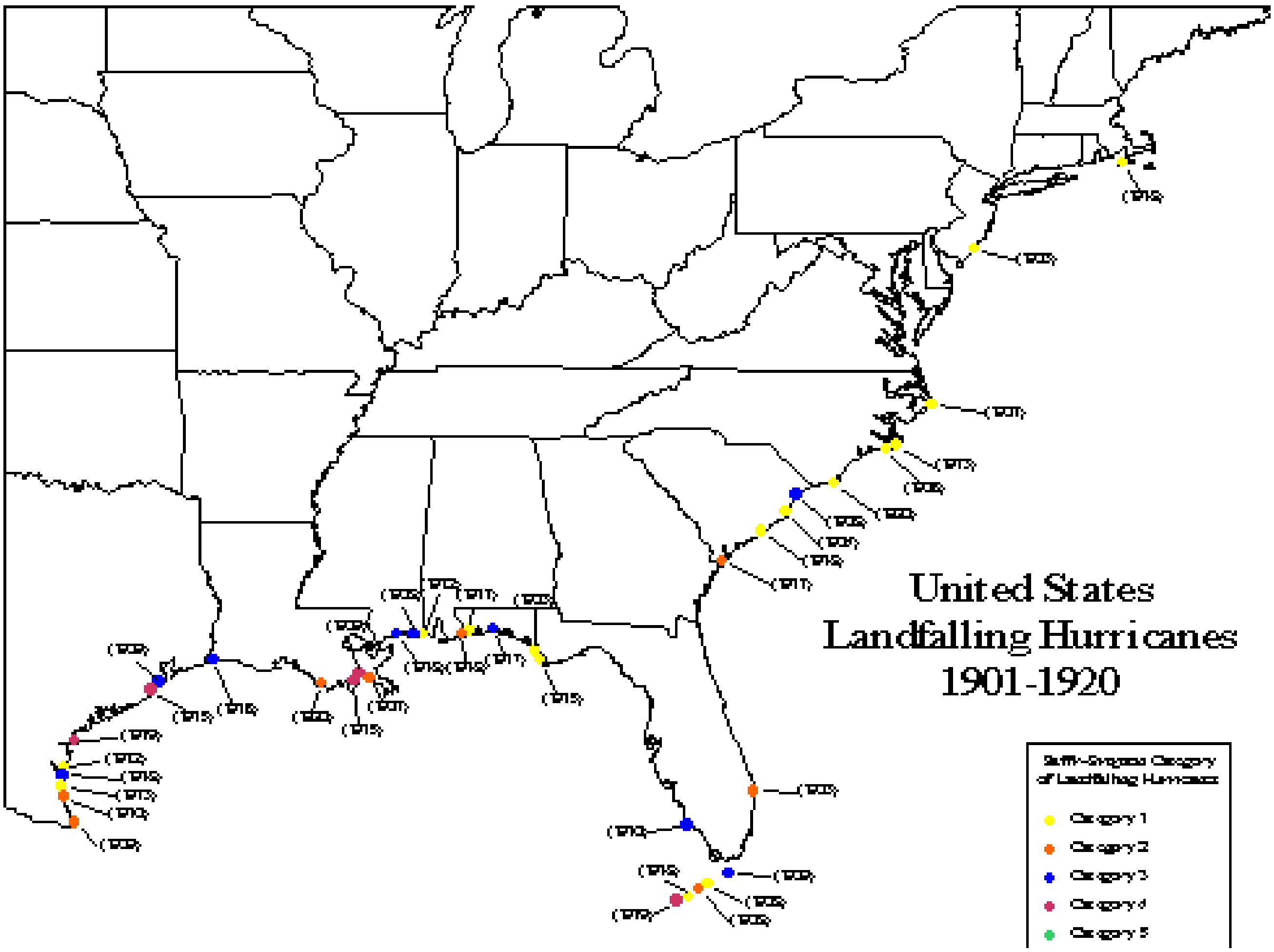
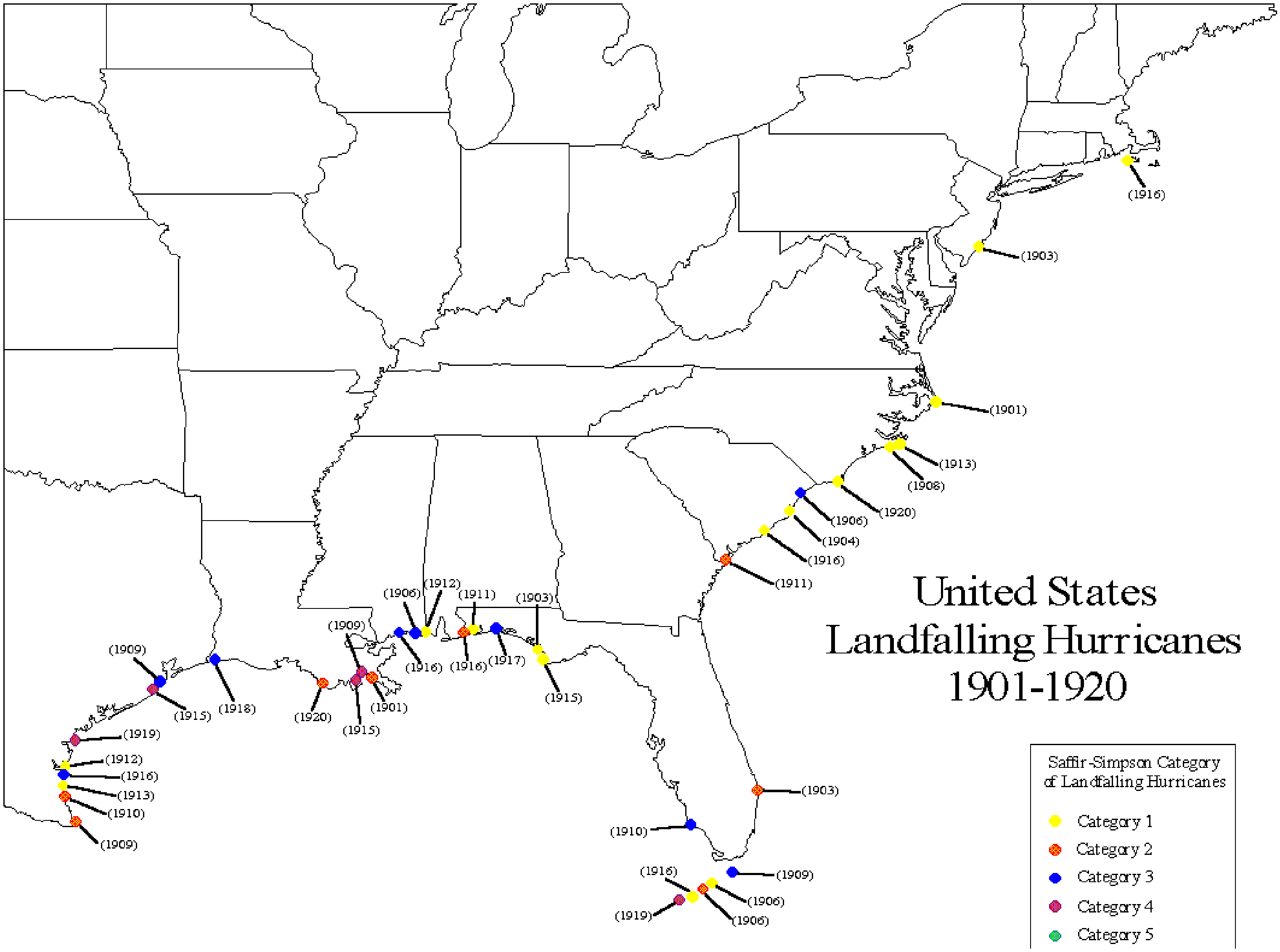

Hurricane Mitch
NOAA-15 HRPT
Multi-spectral Colorized Image
October 27, 1998 13:00 UTC
MEXICO
YUCATAN
PENINSULA
GUATEMALA
15N
HONDURAS
NICARAGUA
90W
80W


CONTINENTAL
UNITED STATES
LANDFALLING HURRICANES
1950-2003
NOAA'S NATIONAL CLIMATIC DATA CENTER, ASHEVILLE, NORTH CAROLINA
PROTECTING THE PAST... REVEALING THE FUTURE


CONTINENTAL UNITED STATES LANDFALLING HURRICANES 1950-2003
Carol (1953)
Gerda (1969)
Edna (1954)
Carol (1954)
Donna (1960)
Gloria (1985)
Edna (1954)
Bob (1991)
Belle (1976)
Isabel (2003)
Connie (1955)
Ione (1955)
Ginger (1971)
Bertha (1996)
Fran (1996)
Diana (1984)
Carol (1954)
Emily (1993)
Gloria (1985)
Barbara (1953)
Charley (1986)
Donna (1960)
Diane (1955)
Floyd (1999)
Bonnie (1998)
Hazel (1954)
Cindy (1959)
Hugo (1989)
Gracie (1959)
Able (1952)
Bob (1985)
David (1979)
Dora (1964)
Danny (1977)
Baker (1950)
Erin (1995)
Opal (1995)
Eloise (1975)
Flossy (1956)
Florence (1953)
Agnes (1972)
Earl (1998)
Alma (1966)
Frederic (1979)
Georges (1998)
Ethel (1960)
Elena (1985)
Kate (1985)
Camille (1969)
Flossy (1956)
Florence (1988)
Betsy (1965)
Bob(1979)
Carmen (1974)
Juan (1985)
Babe (1977)
Danny (1985)
Edith (1971)
Audrey (1957)
Bonnie (1986)
Cindy (1963)
Chantal (1989)
Debra (1959)
Jerry (1989)
Alicia (1983)
Fern (1971)
Carla (1961)
Lili (2002)
Hilda (1964)
Andrew (1992)
Claudette (2003)
Celia (1970)
Bret (1999)
Allen (1980)
Beulah (1967)
Easy (1950)
Gladys (1968)
Donna (1960)
Isbell (1964)
Georges (1998)
Irene (1999)
David (1979)
Erin (1995)
Cleo (1964)
King (1950)
Andrew (1992)
Betsy (1965)
Inez (1966)
Donna (1960)
Floyd (1987)
Saffir-Simpson Category of Landfalling Hurricanes
Sustained Winds (MPH)
74-95 Category 1
96-110 Category 2
111-130 Category 3
131-155 Category 4
>155 Category 5
There were no landfalling hurricanes in the U.S. for the period 2000-2001.
NOAA'S NATIONAL CLIMATIC DATA CENTER, ASHEVILLE, NORTH CAROLINA
PROTECTING THE PAST... REVEALING THE FUTURE


United States
Landfalling Hurricanes
1901-1920


United States
Landfalling Hurricanes
1901-1920
Saffir-Simpson Category of Landfalling Hurricanes
Category 1
Category 2
Category 3
Category 4
Category 5
(1916)
(1903)
(1901)
(1913)
(1908)
(1920)
(1906)
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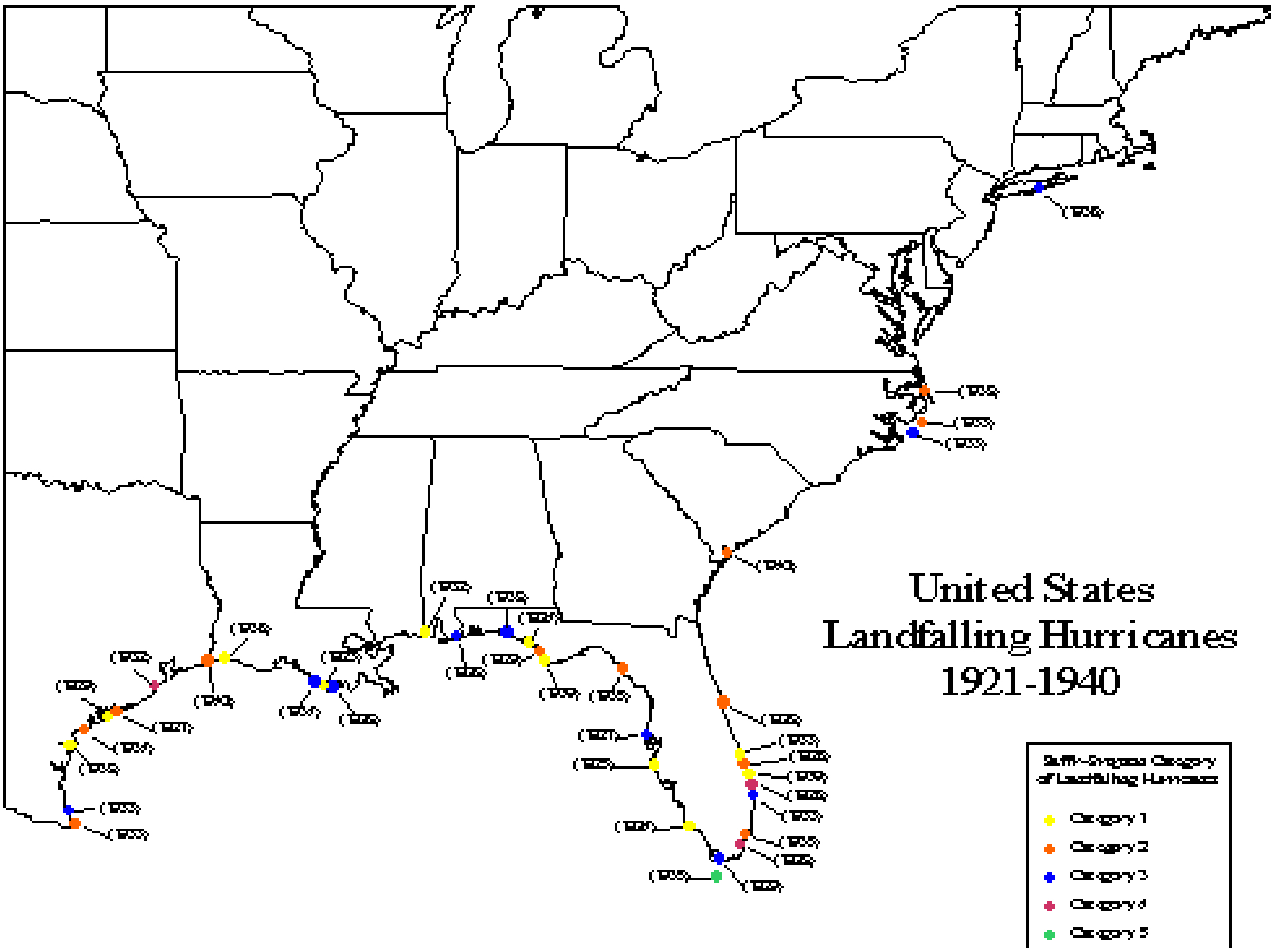
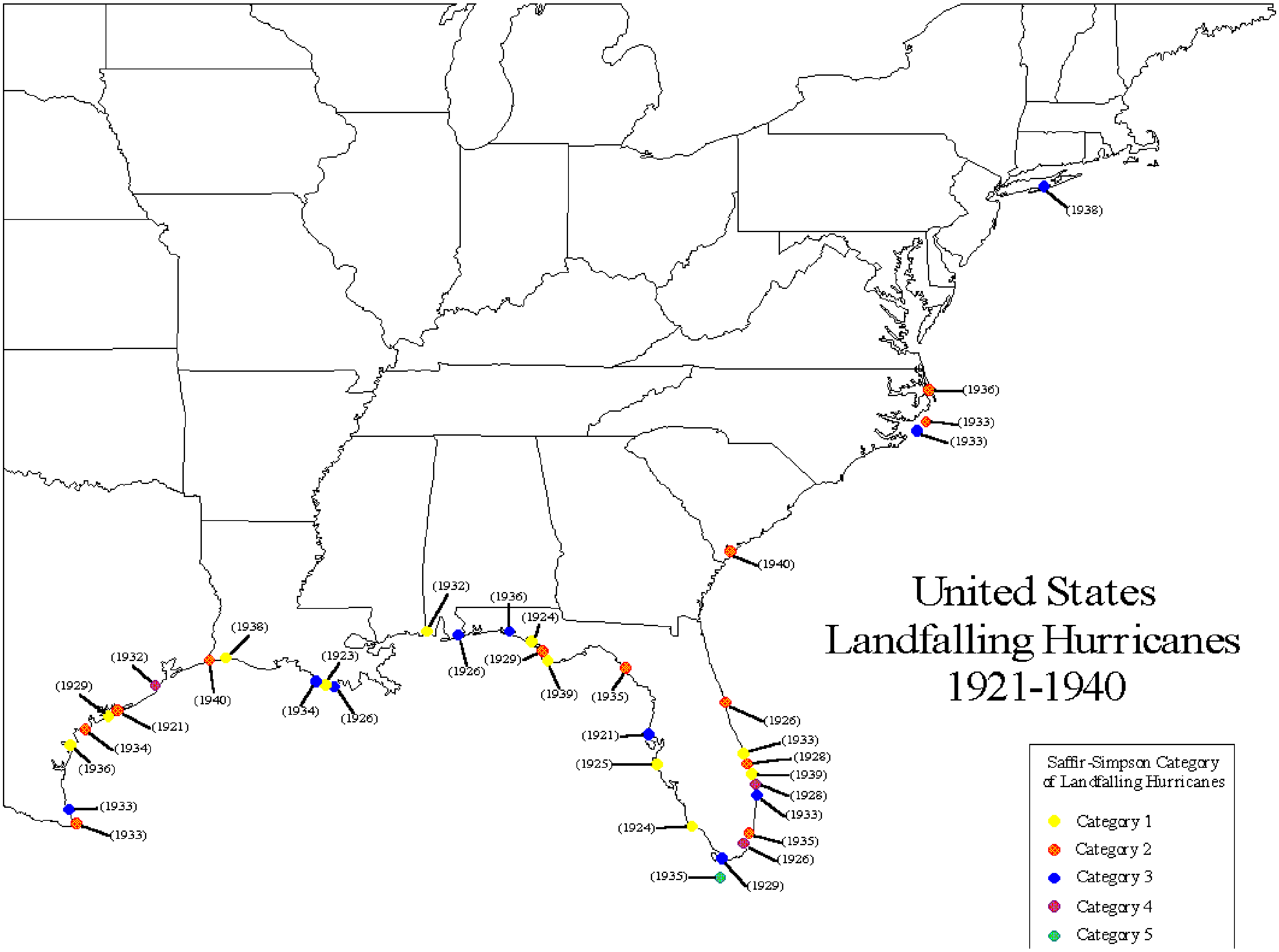
(1916)
(1913)
(1910)
(1909)


United States
Landfalling Hurricanes
1921-1940


United States
Landfalling Hurricanes
1921-1940
Saffir-Simpson Category
of Landfalling Hurricanes
Category 1
Category 2
Category 3
Category 4
Category 5
(1938)
(1936)
(1933)
(1933)
(1940)
(1926)
(1933)
(1928)
(1939)
(1928)
(1933)
(1935)
(1926)
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(1925)
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(1932)
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(1923)
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(1932)
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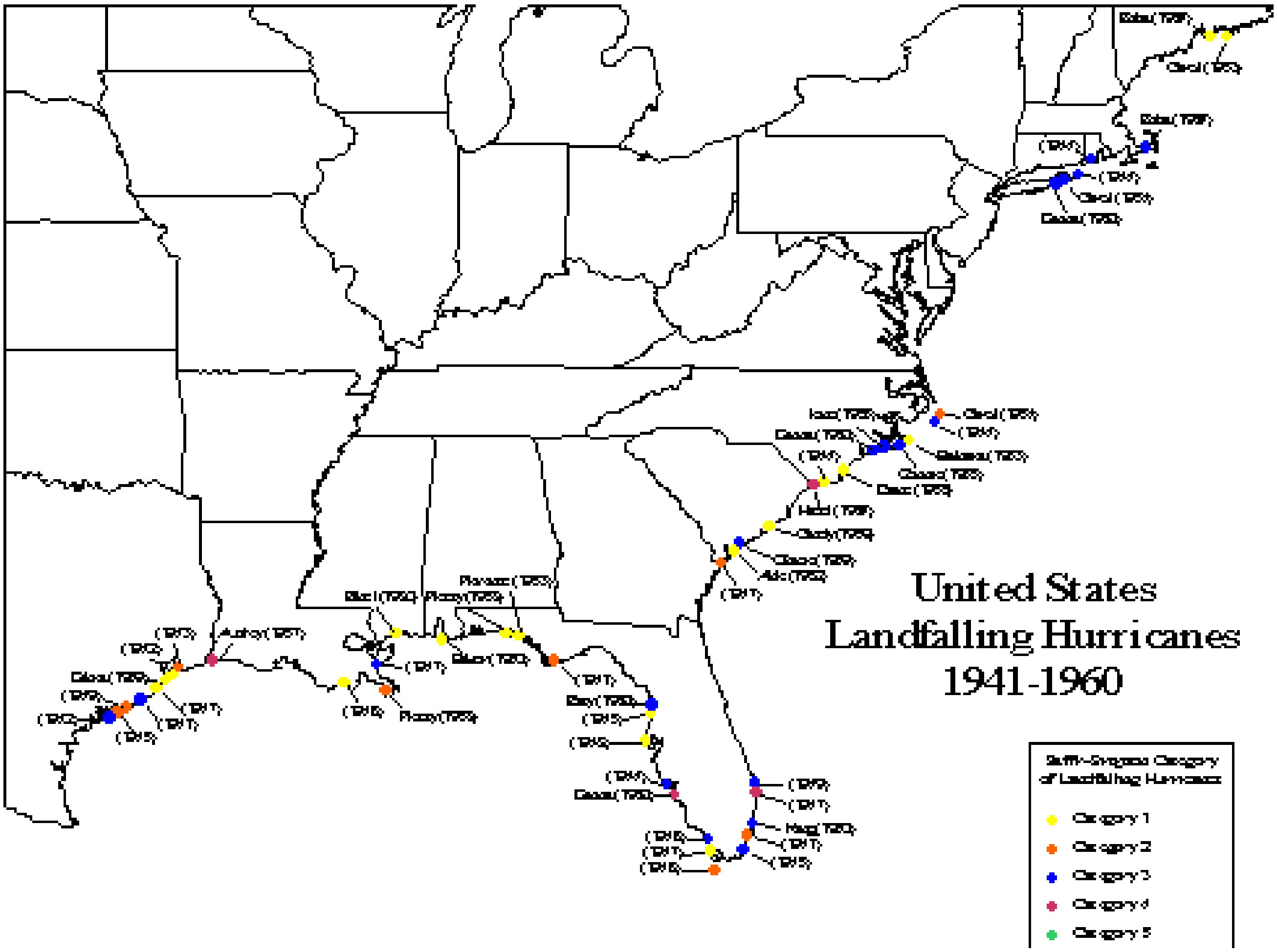
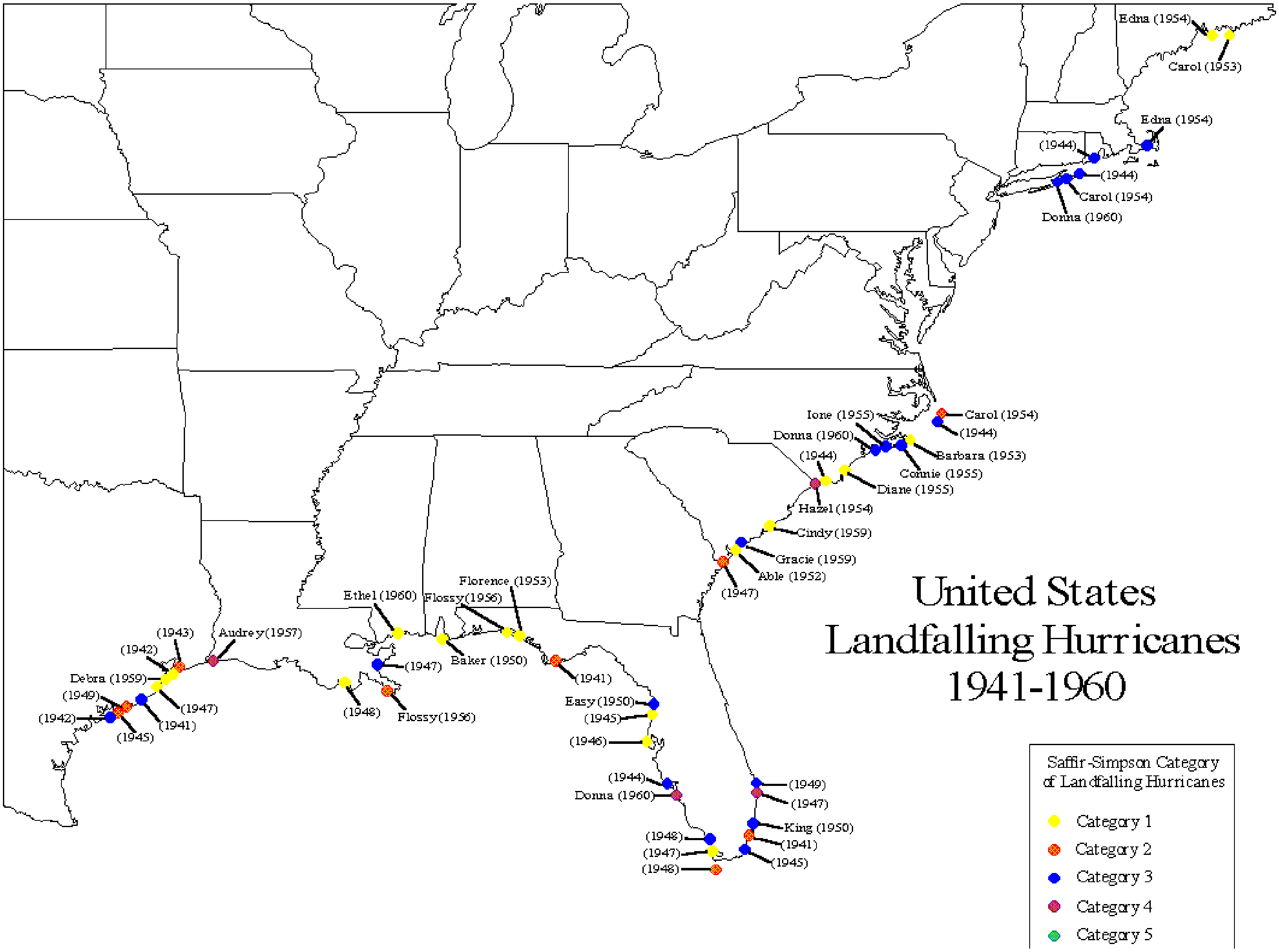
(1934)
(1936)
(1933)
(1933)


United States
Landfalling Hurricanes
1941-1960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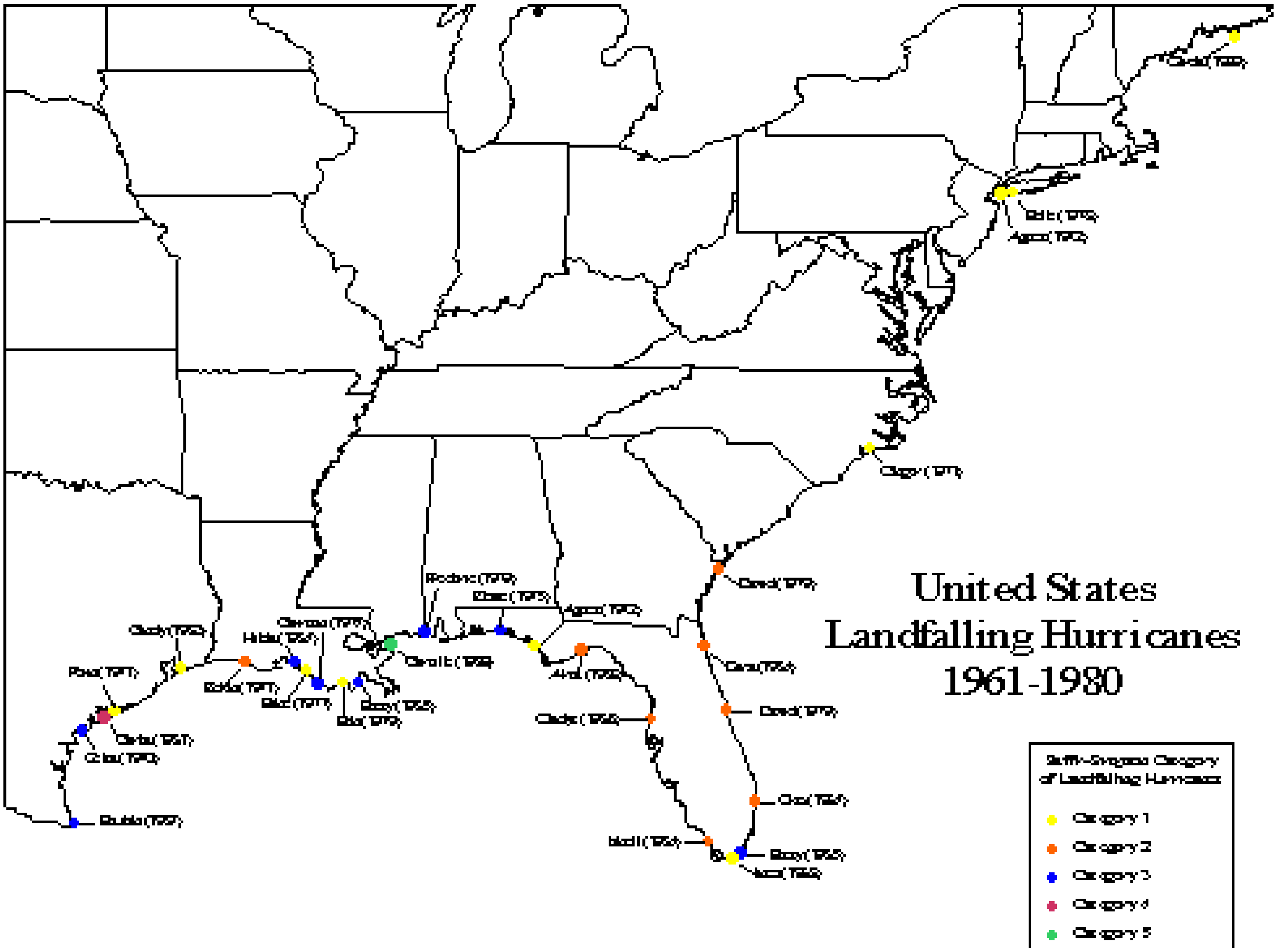
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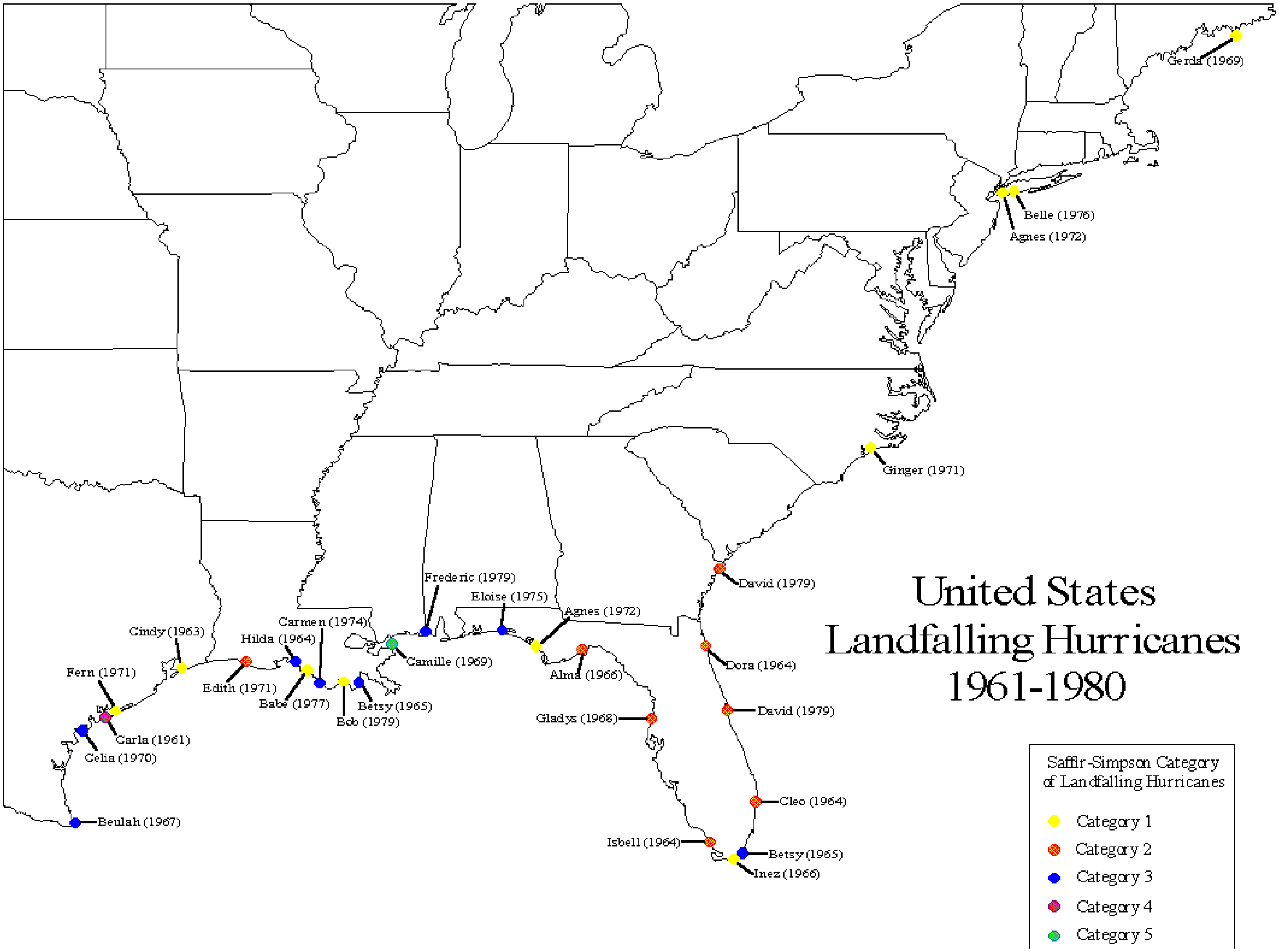
1961-1980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Eloise (1975)
Frederic (1979)
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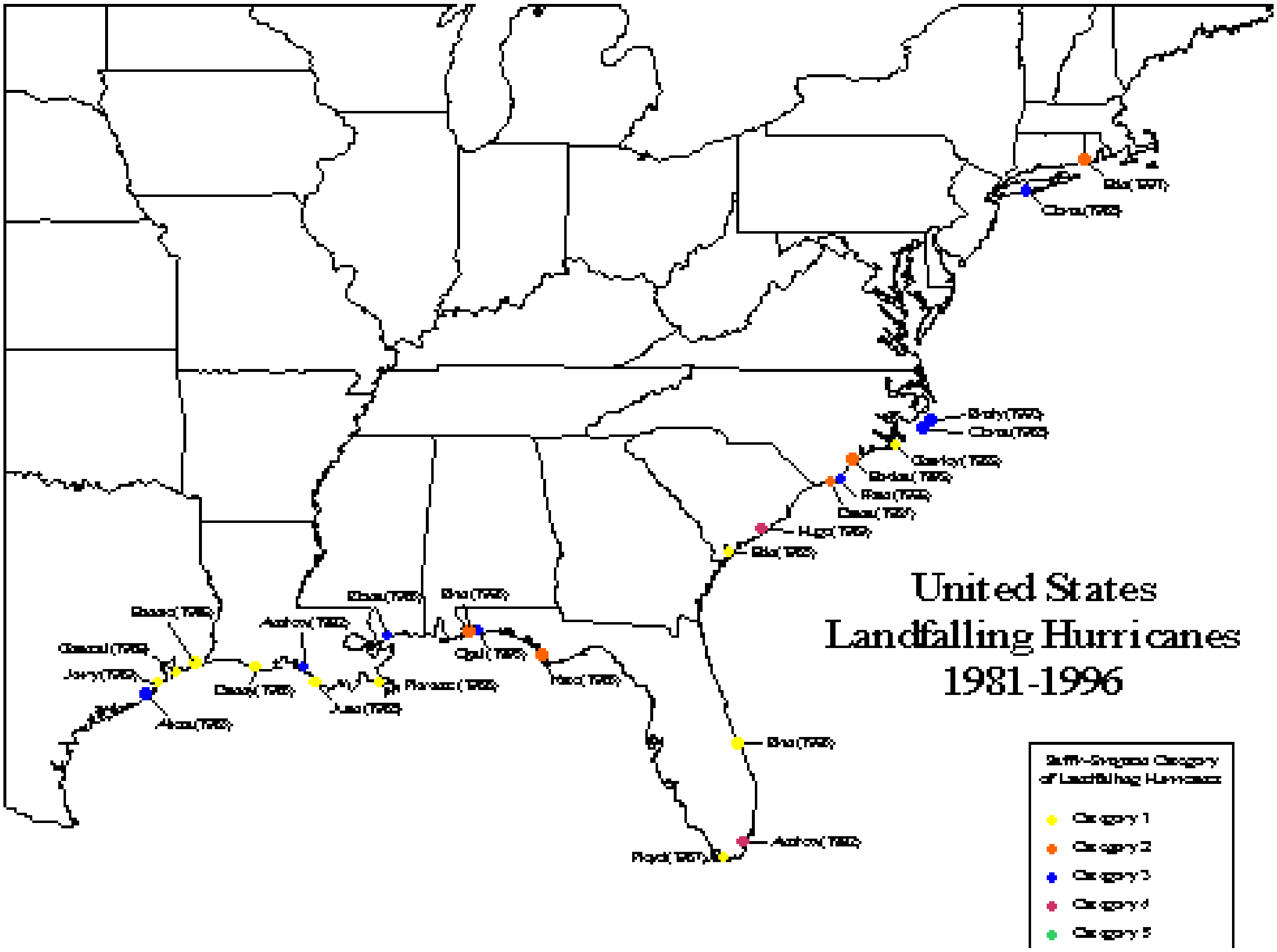
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Landfalling Hurricanes
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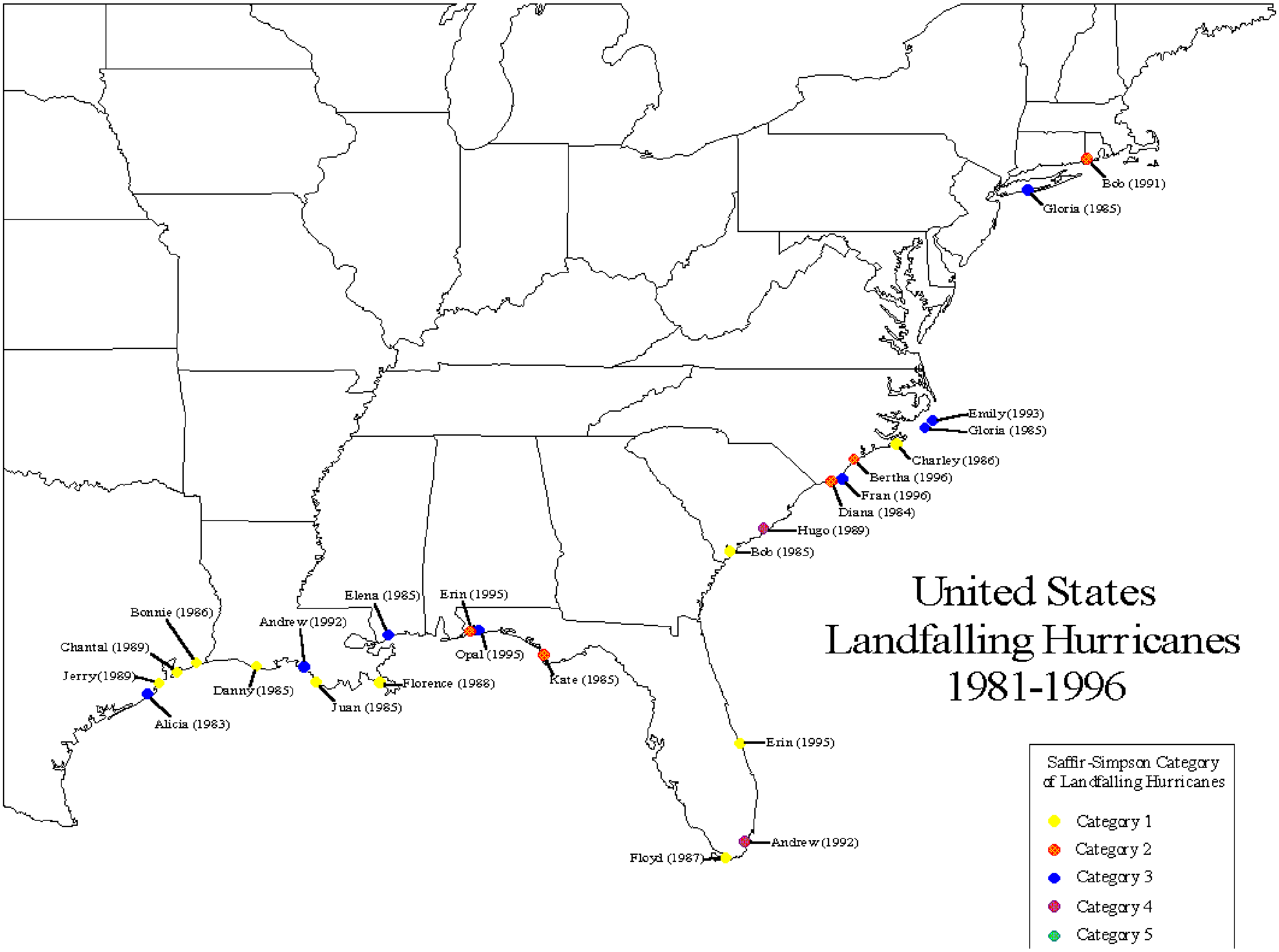
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Diana (1984)
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Bob (1985)
Erin (1995)
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Bonnie (1986)
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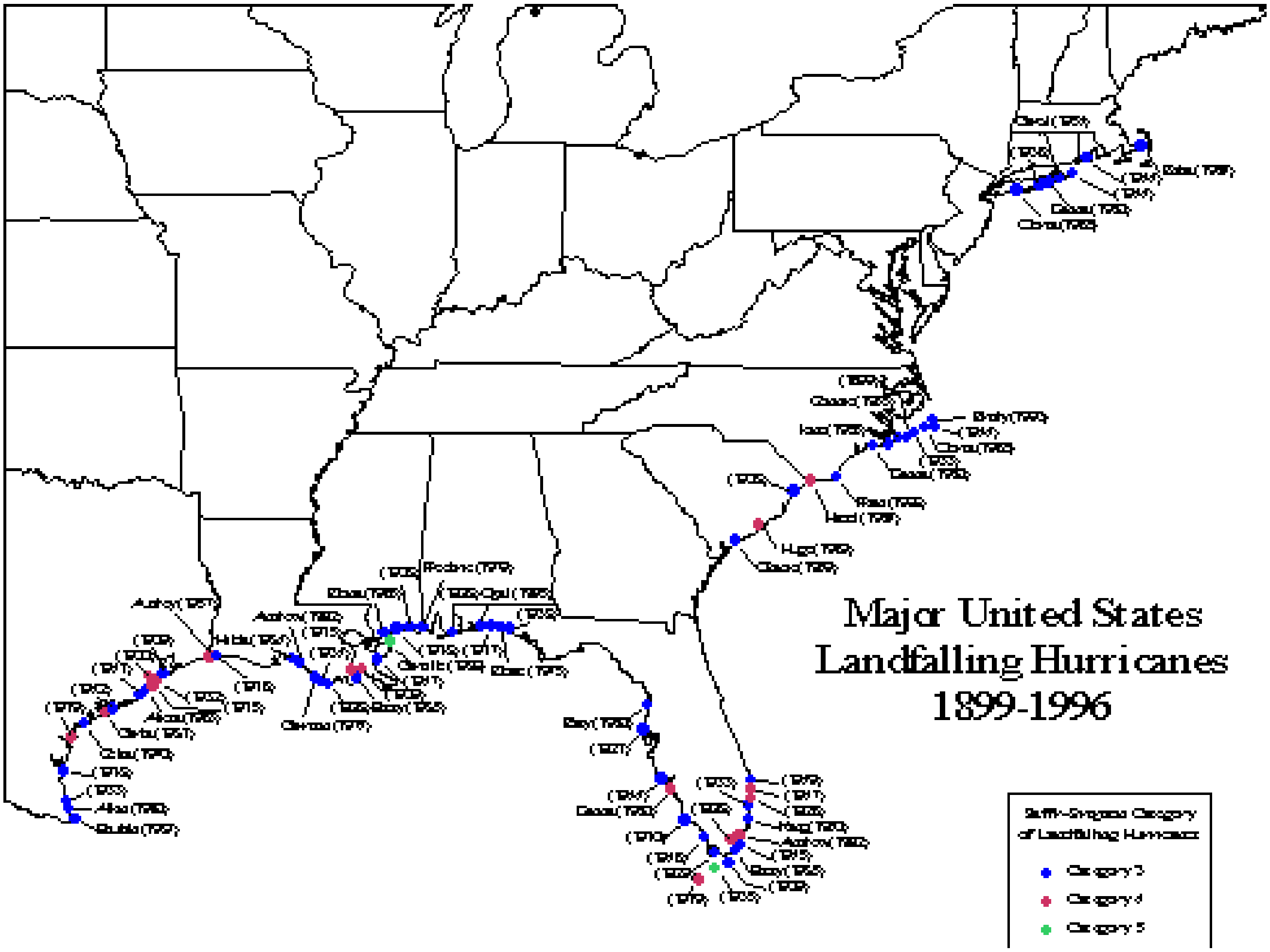
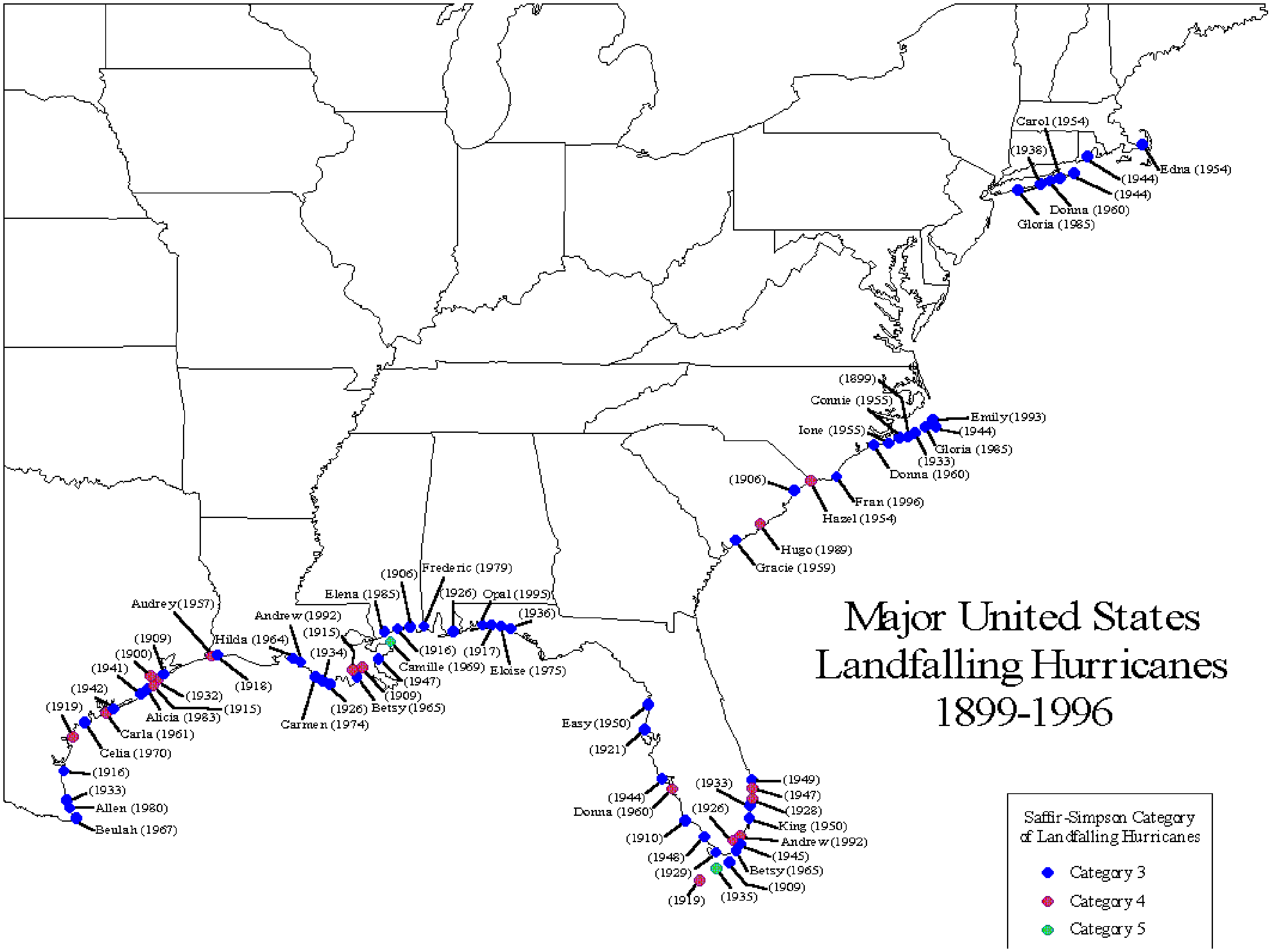

Major United States
Landfalling Hurricanes
1899-1996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Climate of 2003
Atlantic Hurricane Season

National Oceanic Atmospheric Administration Logo

National Climatic Data Center, Last updated - 12 December 2003

Seasonal Summary

As of December 12th, 16 named storms developed in 2003, which is well above the 1944-1996 average of 9.8, but consistent with a marked increase in the annual number of tropical systems since the mid 1990s (1995-2002 average = 13.3). Seven of the named storms were classified as hurricanes and three of those (Fabian, Isabel and Kate) were 'major' (category three or higher on the Saffir-Simpson scale). Two named storms (Odette and Peter) formed after the traditional end of the hurricane season (November 30th). This is the first year since 1887 in which two named storms are known to have formed in December. Tropical Storm Ana formed approximately six weeks before the beginning of the season on April 21st. This is also the first Atlantic storm on record in the month of April. With the development of Tropical Storm Peter in December, 2003 became the longest tropical cyclone season since 1952 when the first tropical storm formed on February 2nd and the last one dissipated on October 28th, according to the NOAA's National Hurricane Center.

Both Isabel and Fabian were very long-lived and instense storms in 2003 and there were five additional tropical depressions which did not reach tropical storm strength. Six storms impacted the coast of the United States. Tropical Storm Bill came ashore in Louisiana in late June and Hurricane Claudette made landfall as a category one hurricane in Texas in July. Tropical Storm Erika brought tropical storm conditions to South Texas though it actually came ashore in Mexico in August. Tropical Storm Grace also affected Texas in late August and Tropical Storm Henri made landfall as a tropical depression in September bringing as much as 10 inches of rain to west-central Florida. By far the largest impact in the United States from this summer's Atlantic storms was from Hurricane Isabel in September. Isabel came ashore in North Carolina as a category 2 hurricane and brought torrential rain and tropical storm force winds to a large area of the mid Atlantic coast. However, Isabel reached category 5 in the Atlantic, the first storm to do so since Hurricane Mitch in 1998. Additionally, Hurricane Juan maintained category 2 strength as it came ashore in Nova Scotia in September becoming the strongest hurricane to impact Halifax in modern history.

There were no tropical storms in November, but two formed in December:

Click Here for a satellite image of TS Odette

larger image

Tropical Storm Odette formed in the Caribbean Sea on December 4th - the first tropical storm on record to have formed in the Caribbean Sea in December. Odette moved Northeastward while strengthening slightly to a maximum intensity of 55 knots, before coming ashore over the Dominican Republic on December 6th. Odette dumped up to 7 inches of rain before moving off the northeast and merging with a cold front moving off the coast of the United States.

Tropical Storm Peter formed on December 9th in the eastern Atlantic and initially moved southwest and south over warmer waters. Peter then intensified rapidly to a maximum intensity of 60 knots (just below hurricane strength) while moving north. However, Peter just as rapidly deteriorated to become a tropical depression on December 10th.

Click Here for a satellite image of Tropical Storm Peter

larger image

October

Four named tropical systems, including one major hurricane occurred in October, compared to a long-term average of approximately one tropical storm and one hurricane for the month. Major Hurricane Kate formed in September and completed its lifecycle during October becoming 'major' during the early part of the month, and tropical storms Larry, Mindy and Nicholas also formed during October 2003.

Click Here for a satellite image of Hurricane Kate

larger image

Hurricane Kate strengthened at the beginning of October after forming in the central Atlantic on September 25th. Maximum windspeeds of 125 mph were reached on October 4th while the hurricane was located about 640 miles east of Bermuda. Kate began to weaken over the next several days as it moved north and west and lost its tropical characteristics several hundred miles east-northeast of Newfoundland on October 8th. Still a powerful extratropical storm, Kate continued across the north Atlantic until it merged with a low pressure system close to Norway a couple of days later.

Tropical Storm Larry developed in the southern Gulf of Mexico on the 1st and trekked slowly southward into the Bay of Campeche, making landfall just east of Coatzacoalcos, Mexico on the 5th with maximum sustained winds near 85 km/hr (45 knots or 50 mph). Larry brought heavy rain to areas of Tabasco and Veracruz states, and prompted the temporary closure of two oil export ports of Dos Bocas and Pajaritos (Reuters).

Click Here for a satellite image of Tropical Storm Larry on

larger image

September

Tropical Storm Henri developed in the eastern Gulf of Mexico on the 3rd and weakened into a tropical depression before crossing Florida on the 6th. The effects of Henri were minimal, with some localized heavy rain (up to 10 inches in west-central Florida) and gusty winds. Henri dissipated by the 8th.

Hurricane Isabel:

A tropical wave moving off the shore of Africa developed into Tropical Storm Isabel in the far eastern Atlantic, near the Cape Verde Islands on September 6th, 2003. The next day, as it moved west-northwestward, Isabel developed an eye and reached hurricane strength on the 7th. Conditions were very favorable for Isabel's continued development with warm sea surface temperatures ahead of it, low shear and an impressive outflow pattern from the storm. Rapid intensification occurred over the next several days and Isabel became a category 5 hurricane on the 11th. Isabel weakened slightly on the 13th, but did not weaken considerably until overnight on the 15th/16th when westerly shear began to affect the storm. Isabel decreased in strength to a category 2 storm, and eventually came ashore along North Carolina's Outer Banks on September 18th with sustained winds of approximately 85 knots - a minimal category 2 storm.

Hurricane Isabel

larger image

Hurricane Isabel

larger image

Preliminary estimates of Isabel's precipitation indicate that interior Virginia bore the brunt of the rainfall from Hurricane Isabel. The rainfall from Isabel did not lead to widespread flooding throughout North Carolina and Virginia. However, the unusually high precipitation totals in the months that preceded Hurricane Isabel resulted in very wet soils, and the combination of the wet conditions and strong winds associated with the storm led to downed trees and power outages for millions of people in the mid-Atlantic and Northeast. Most of the flooding associated with storm occurred at the coastal margin. Hurricane force winds and a storm surge of as much as 7-10 feet associated with Isabel led to a great deal of destruction at Cape Hatteras, NC, as well as along coastal Virginia and Maryland. Preliminary estimates suggest that 38 people died as a result of Isabel.

A comparison between Isabel and 2 other major mid-Atlantic hurricanes of recent years is also available.

Hurricane Juan initially appeared to be subtropical in nature, but after forming approximately 295 miles southeast of Bermuda on September 25th, it moved to the north-northwest and was classified as fully tropical. Maximum windspeeds of 105 mph (91 kts) were reached on the 27th as Juan continued to move northward and made landfall in Nova Scotia, near Halifax the following day with somewhat weaker windspeeds. Juan was a category 2 hurricane at landfall - the strongest storm to hit Halifax in its modern history. Eight deaths have been attributed to Juan.

Satellite image of Hurricane Juan

larger image

Hurricane Kate began as a tropical wave approximately 900 miles west-southwest of the Cape Verde Islands on September 25th. The system became a tropical storm on the 27th. Briefly reaching hurricane strength on the 29th, by the end of the month Kate was located about 600 miles southwest of the Azores. More information on Kate can be found in the October section.

August

Hurricane Fabian was the only hurricane to develop during the month of August, though in total, there were four tropical systems that formed during the month. Fabian was the first 'major' hurricane of the season (category three or higher on the Saffir simpson scale), and eventually reached category four strength. The storm was a 'Cape Verde hurricane' developing on August 27th about 370 miles (596 km) west of the Cape Verde Islands. Tropical storm strength was reached on the 28th and Fabian became a hurricane on the 29th, reaching 'major hurricane' status on the 30th. Fabian reached category four strength on the 31st, but did not reach maximum windspeeds of 125 kts (144 mph, 231 kph) until September 1st. As the storm recurved in the western Atlantic, hurricane warnings were issued for the island of Bermuda and Fabian's eye passed very slightly to the west of the island on the afternoon of September 5th. Four deaths in Bermuda were directly blamed on the storm.

Satellite image of Hurricane Fabian

larger image

Other named tropical systems in August were Erika and Grace, with short-lived Tropical Depression #9 also developing in the eastern Caribbean. TD #9 developed on August 21st from a fast-moving tropical wave. The depression dissipated south of Hispaniola the following day after moving west-northwestward.

Tropical Storm Grace developed at the end of August from a tropical wave which traveled across Mexico's Yucatan Peninsula and into the southeastern Gulf of Mexico on the 29th. The storm never became very organized, but was of tropical storm strength by the time it made landfall at Port O' Connor, Texas on August 31st with maximum sustained winds near 65 km/hr (35 knots or 40 mph). Heavy rainfall was the primary impact of Grace, with 50-130 mm (2-5 inches) common along parts of the Texas Gulf Coast.

Click Here for a satellite image of Tropical Storm Grace near the Texas coast on August 31, 2003

larger image

Satellite image of Tropical Storm Erika south of Brownsville, TX on August 16, 2003

larger image

Tropical Storm Erika developed in the eastern Gulf of Mexico on the 14th and crossed into northern Mexico about 45 miles (70 km) southeast of Brownsville, TX in the United States on the 16th. Maximum sustained winds at the time of landfall were near 60 kts (110 km/hr or 70 mph). No significant damage or flooding was reported in south Texas, although trees were downed and roof damage occurred along the coast of northern Mexico (Associated Press).

July

Hurricane Claudette

larger image

Tropical Storm Claudette developed in the central Caribbean Sea on July 8th about 415 miles (670 km) east-southeast of Kingston, Jamaica. The storm strengthened and moved rapidly across the Caribbean Sea during the following 24 hours. Claudette maintained strength and moved west and then northwest before weakening as it entered the Gulf of Mexico, clipping the Yucatan coast of Mexico. It then moved very slowly through the Gulf of Mexico over the weekend of the 12th and 13th while gradually strengthening to reach category 1 hurricane strength late on July 14th. **The first Atlantic hurricane of the season,** Hurricane Claudette finally made landfall on the morning of July 15th around Port O'Connor, Texas, with maximum sustained winds at around 75 mph (120 kph/65 kts).

The storm left two Texas residents dead and thousands without power along the central Texas coast before being downgraded to a tropical depression on the 16th. However, Claudette also brought welcome moisture to parts of Texas and the Southwest which had been dry.

Hurricane Danny began east of Bermuda as Tropical Depression #5 on July 16th and rapidly developed into a tropical storm later the same day. While posing no threat to land, Danny moved northward and then northeastward and became the second hurricane of the season on July 18th. Hurricane Danny weakened back to tropical storm status on the 19th as it tracked east-southeast across the North Atlantic.

Tropical Storm Danny

larger image

Tropical Depressions #6 and #7 also formed during July, but neither one was long-lived. TD #6 formed on the 19th and degenerated into a tropical wave by the 21st. Some thunderstorm activity was observed over the Lesser Antilles as a result of this system. TD #7 formed on July 25 and came ashore in Georgia on the 26th. Sustained winds were at 30 mph (48 kph/26 kts) at landfall and 2-3 inches (51-76 mm) of rain fell in parts of Georgia and South Carolina from the tropical system.

June

Tropical Storm Bill rapidly developed in the Gulf of Mexico on Sunday June the 29th and came ashore in Southeastern Louisiana on Monday June 30th with sustained winds of 60 mph (97 kph/52 kts). Thousands of homes in Louisiana lost power during the storm and damaging rainfall amounts associated with Bill and its remnants caused flooding in states throughout the Southeast. At least 8 inches (203 mm)of rain fell in Pascagoula, Mississippi (on the border with Alabama) though rainfall and tornadoes also caused problems into Mississippi, Alabama, Tennessee, Georgia, North Carolina and Virginia. For further information on tropical systems affecting the Southeast U.S., go to the Southeast Regional Climate Center

Tropical Storm Bill

larger image

Tropical Depression #2 also formed in the Atlantic on June 10, but rapidly degenerated into a tropical wave just one day later. However, it is only the third tropical cyclone to form east of the Lesser Antilles in June since 1967, according to the NOAA's National Hurricane Center.

Pre-Season

Tropical Storm Ana

larger image

The first tropical storm of the year, named Ana (shown left), formed more than five weeks before the official start of the hurricane season in 2003. The Atlantic hurricane season officially begins on June 1st, but a sub-tropical storm developed on April 20th and became a tropical storm on the 22nd. Maximum sustained winds reached 50 mph (80 km/hr, 45 knots) and the storm dissipated on the 23rd without nearing land. While tropical storms can form throughout the year in the North Atlantic, they are comparatively rare between the beginning of December and the end of May. Ana was the earliest storm of the Atlantic hurricane season since 1978 and the only tropical storm on record ever to have formed in April in the Atlantic Basin. According to NOAA's National Hurricane Center, the season's earliest Atlantic hurricane ever recorded was on March 7th, 1908, while the latest was on December 31st, 1954, which persisted into January 1955.

Useful Links

- Saffir-Simpson Scale

- NOAA's National Hurricane Center
- Southeast Regional Climate Center - for tropical systems affecting the Southeast.

Questions?

For all climate questions other than questions concerning this report, please contact the National Climatic Data Center's Climate Services Division:

Climate Services Division
NOAA/National Climatic Data Center
151 Patton Avenue
Asheville, NC 28801-5001
fax: 828-271-4876
phone: 828-271-4800
email: questions@ncdc.noaa.gov

For further information on the historical climate perspective presented in this report, contact:

Jay Lawrimore
NOAA/National Climatic Data Center
151 Patton Avenue
Asheville, NC 28801-5001
fax: 828-271-4328
email: Jay.Lawrimore@noaa.gov

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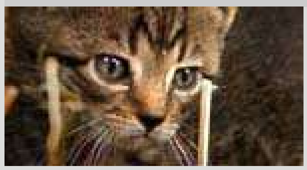

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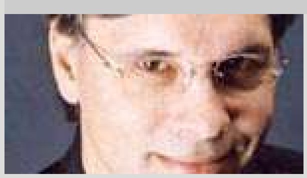

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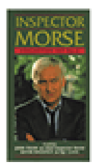

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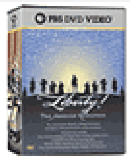

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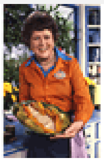

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Why the Towers Fell: Forensic engineers investigate the collapse of the World Trade Center. Airs on PBS Tuesday, September 7 at 8 p.m.

Coming up on TV | Recent NOVAs | We recommend | Interests

Coming up on TV

Infinite Secrets
A battered manuscript turns up after 1,000 years, revealing the mind of the Greek genius Archimedes. September 14 at 8 pm

Origins
Journey back to the beginning of everything: the universe, Earth, and life itself. September 28 from 8 to 10 pm and September 29 from 8 to 10 pm

The Perfect Pearl
Once a rare gem produced by an accident of nature, the pearl is now the product of careful human engineering. October 5 at 8 pm

Complete TV Schedule

Check local listings as dates and times may vary.

Recent NOVAs

Battle of the X-Planes
Two aviation giants, Lockheed Martin and Boeing, compete to build the next-generation fighter jet.

Last Flight of Bomber 31
Forensic scientists set out to discover what happened to seven American airmen whose plane crashed in Kamchatka during World War II.

Lost at Sea:
The Search for Longitude
How the quest for a reliable method to find your way at sea was solved by an 18th-century English clockmaker.

We recommend

Life's Greatest Miracle
Lennart Nilsson's microphotography chronicles the growth of a baby from embryo to newborn.

Galileo's Battle
for the Heavens
Galileo struggles to persuade church authorities of the truth behind his astonishing discoveries about the cosmos.

Watch NOVA Online
Choose from among nine hours of NOVA programming viewable entirely online.

Interests

Anthropology

Disasters

Earth

Exploration

Flight

Forensics

Health

History

Nature

Physics & Math

Space

Technology

Support authoritative science programming like NOVA by making a pledge to your local PBS station. Pledge now.

PBS/WGBH

Major funding for NOVA is provided by the Park Foundation, Sprint, and Microsoft.

Park Foundation, Sprint, Microsoft

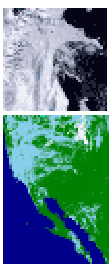
Additional funding provided by the Corporation for Public Broadcasting and viewers like you.

CPB

National Snow and Ice Data Center

SUPPORTING CRYOSPHERIC RESEARCH SINCE 1976

NSIDC Data



DATA PRODUCTS & SERVICES
Hundreds of data sets. Data provider information. Data news. Data tools. Data search. Data help.

NSIDC provides cryospheric data and information gathered from such sources as remote sensing instruments, ground measurements, and models.

Sponsored Activities

Explore the Cryosphere

THE CRYOSPHERE
WHERE THE WORLD IS FROZEN
Snow. Ice. Sea ice. Freshwater ice. Frozen ground. Glaciers. Ice shelves and Icebergs.

State of the Cryosphere: scientific synopsis and data snapshots of the cryosphere and climate change.

NEWS & FEATURES

NSIDC NEWS
Cryospheric data and the cryosphere in the news at NSIDC and elsewhere.

04 August 2004
A preliminary agenda and online registration are now available for the Workshop on EOS Snow and Ice Products in Greenbelt, Maryland, 16-17 November 2004.

14 July 2004
Job Announcement
NSIDC has two openings for an Information Center Lead. Please see the full job description for details.

SPONSORED DATA PROJECTS
Data management programs and projects. Data centers at NSIDC.

SPONSORED RESEARCH
Funded scientific investigations underway at NSIDC.

ABOUT NSIDC
Expertise. History. Our director. Job announcements. Directions. Staff Directory. Users. Sponsors.

IMAGE & PHOTO GALLERY
Data related images. Satellite imagery. Historic photos.

NSIDC PUBLICATIONS
Quarterly newsletter. Glaciological data series. Special data reports.

NSIDC EVENTS
Meetings. Conferences. Symposiums. Workshops.

The National Snow and Ice Data Center (NSIDC)
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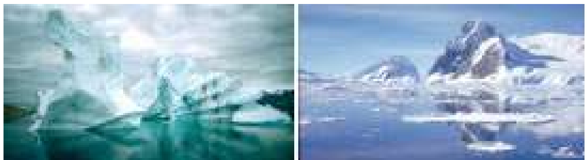
nsidc@nsidc.org | NSIDC privacy policy



About NSIDC

National Snow and Ice Data Center
449 UCB,
University of Colorado
Boulder, CO 80309-0449
303.492.6199
nsidc@nsidc.org

About the National Snow and Ice Data Center

OUR MISSION

"NSIDC/WDC will make fundamental contributions to cryospheric science and will excel in managing data and disseminating information in order to advance understanding of the Earth system."

NSIDC is part of the University of Colorado Cooperative Institute for Research in Environmental Sciences, and is affiliated with the National Oceanic and Atmospheric Administration National Geophysical Data Center through a cooperative agreement. NSIDC serves as one of eight Distributed Active Archive Centers funded by the National Aeronautics and Space Administration to archive and distribute data from NASA's past and current satellites and field measurement programs. NSIDC also supports the National Science Foundation through the Arctic System Science Data Coordination Center and the Antarctic Glaciological Data Center.

Established by NOAA as a national information and referral center in support of polar and cryospheric research, NSIDC archives and distributes digital and analog snow and ice data. We also maintain information about snow cover, avalanches, glaciers, ice sheets, freshwater ice, sea ice, ground ice, permafrost, atmospheric ice, paleoglaciology, and ice cores.

NSIDC publishes reports and a quarterly newsletter, and creates and distributes data products on CD-ROM and other media. It also holds a large library collection of monographs, technical reports, and journals.

Additional information is available in the NSIDC Annual Report, 2001 (PDF file, ~2.1 MB)

University of Colorado at Boulder

Cooperative Institute for Research in Environmental Sciences (CIRES)

National Oceanic and Atmospheric Administration (NOAA)

- National Geophysical Data Center (NGDC)
- NOAA at NSIDC

National Aeronautics and Space Administration (NASA)

- NASA Distributed Active Archive Center (DAAC) at NSIDC

National Science Foundation (NSF)

- NSF Arctic System Science Data Coordination Center (ADCC) at NSIDC
- NSF Antarctic Glaciological Data Center (AGDC) at NSIDC

The National Snow and Ice Data Center (NSIDC)
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CIRES, 449 UCB University of Colorado Boulder, CO 80309-0449

Google Search

See Also
Site Map/Index
Search Data Sets

Site Map/Index

For driving directions and maps, see directions to NSIDC.

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A

A B C D E F G H I J K L M N O P Q R S T U V W X-Z

B

- biosphere data
- blizzards

A B C D E F G H I J K L M N O P Q R S T U V W X-Z

C

- citing NSIDC data
- climate and meteorology, arctic
- climate change: see State of the Cryosphere
- climate modeling grid browse images
- Cold Facts: Earth's Snow, Ice and Frozen Soils
- Cold Land Processes Experiment (CLPX) data at NSIDC
- Cold Land Processes Workshop, 2003
- ColdLinks: NSIDC's cryospheric referral center
- contacting NSIDC
- contributing data to NSIDC
- Cryosphere - Cold Facts: Earth's Snow, Ice and Frozen Soils
- Cryosphere - Cryosphere at a glance
- Cryosphere - glaciers, ice shelves, snow, arctic meteorology, Antarctic megadunes
- Cryosphere - State of the Cryosphere

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D

- DAAC: DAAC data | DAAC projects
- data at NSIDC: data help center
- Data Pool
- data management @ NSIDC
- data tools
- digital elevation models and topographic data
- directions to NSIDC
- director of NSIDC

- directory of staff
- Distributed Active Archive Center: DAAC at NSIDC

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E

- EASE-Grid
- education links to snow and ice content elsewhere on the Web
- elevation data: Polar Ice Sheet DEMs and Elevation Data
- EOS Data Gateway (will open new window)
- events
- Environmental Working Group (EWG) data at NSIDC
- EOS Data Gateway

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F

- formats, data : see data help center: formats and media
- Frozen Ground Data Center (WDC)

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G

- gallery
- gallery, brightness temperatures images
- gallery, climatology and meteorology
- gallery, glaciers
- gallery, MODIS
- gallery, RAMP
- gallery, snow
- gallery, see also images of Antarctic ice shelves
- gallery, see also MODIS images
- gallery, see also NASA Earth Observatory Images
- gallery, see also NSIDC staff photos

- gallery, see also sea ice concentration images
- gallery, see also snow cover and sea ice extent images
- GDSIDB: Global Digital Sea Ice Data Bank
- Ice, Cloud, and Land Elevation Satellite/Geoscience Laser Altimetry System
- GISP2: Greenland Ice Sheet Project 2
- glaciers
- glaciers as an indicator of climate change: see State of the Cryosphere
- Glaciological Data Series, an NSIDC/WDC publication
- glaciology, see Glaciology on the World Wide Web, All About Glaciers
- ICESat/GLAS: Ice, Cloud, and land Elevation Satellite/ Geoscience Laser Altimetry System
- GLIMS Data at NSIDC
- Global Digital Sea Ice Data Bank (GDSIDB)
- Global Land Ice Measurements from Space (GLIMS)
- glossary, climatology and meteorology
- glossary, glaciers
- glossary, snow
- Greenland Ice Sheet Project 2 (GISP2)

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H

- HARC: Human Dimensions of the Arctic System
- HDF-EOS: Hierarchical Data Format - Earth Observing System
- help with data : see data help center
- history of NSIDC
- Human Dimensions of the Arctic System
- hydrology, see: Bibliography on the Hydrology of the Himalaya-Karakoram Region
- hydrosphere data

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I

- ice cores, questions and answers
- ice core records & paleoclimate data
- ice sheets, see also: Polar Ice Sheet DEMs and Elevation Data
- ice sheets, questions and answers
- ice shelves
- ice shelves: images of Antarctic ice shelves
- ice velocity data for Antarctica
- icebergs
- iceberg images sites
- iceberg links
- iceberg questions and answers
- IDL access tools for browsing and visualizing P-cube and TOVS Polar Pathfinder (Path-P) data files
- IICWG: International Ice Charting Working Group
- images of Antarctic ice shelves
- images - see the NSIDC gallery and the web photo gallery section of ColdLinks
- indicators of climate change: see State of the Cryosphere
- International Ice Charting Working Group
- international interactions
- investigators at NSIDC: see NSIDC researchers

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J

- job announcements

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L

- LAII: Land/Atmosphere/Ice Interactions
- lake data, see Lake and River Ice Phenology
- land surface data
- Land/Atmosphere/Ice Interactions

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M

- maps and directions to NSIDC
- meteorology and climate, arctic
- Midwest Glaciology Meeting, 8th Annual: see events
- mission of NSIDC
- MODIS project: MODIS (Moderate Resolution Imaging Spectroradiometer) data

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N

- NASA Distributed Active Archive Center
- National Oceanic & Atmospheric Administration (NOAA) and NSIDC
- new products
- news
- NOAA @ NSIDC
- NOAA/NASA Pathfinder project: NOAA/NASA Polar Pathfinder Data
- NSF Arctic System Science (ARCSS) Data Coordination Center at NSIDC
- NSF Antarctic Glaciological Data Center at NSIDC
- NSF U.S. Antarctic Data Coordination Center at NSIDC
- NSIDC Notes

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O

- OAII: Ocean/Atmosphere/Ice Interactions
- oceans data

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P

- paleoclimate data & ice core records
- PARCA: Program for Arctic Regional Climate Assessment
- PARCS: Paleoenvironmental Arctic Science
- Pathfinders, NOAA/NASA: Polar Pathfinder Data
- permafrost as an indicator of climate change: see State of the Cryosphere
- permafrost links
- permafrost, see also: Frozen Ground Data Center
- permafrost, see also: Circumpolar Active-Layer Permafrost System (CAPS) CD-ROM
- permafrost, see also: Global Geocryological Data (GGD) System
- photos, see the NSIDC Gallery and the web photo gallery section of ColdLinks
- Polar Pathfinder project: Polar Pathfinder Data
- product news
- Program for Arctic Regional Climate Assessment (PARCA)
- projects
- publications at NSIDC and cryospheric publications elsewhere on the Web

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Q

- questions and answers about blizzards
- questions and answers about glaciers
- questions and answers ice cores
- questions and answers ice sheets
- questions and answers about icebergs
- questions and answers about snow

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R

- Radarsat Antarctic Mapping Project: RAMP data at NSIDC
- RAMP: Radarsat Antarctic Mapping Project: RAMP data at NSIDC
- research @ NSIDC
- researchers @ NSIDC
- river ice data, see Lake and River Ice Phenology

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S

- sea ice index
- sea ice products
- Sea Ice Trends and Climatologies from SMMR and SSM/I
- search for data products
- SHEBA: SHEBA Reconnaissance Imagery
- snow
- snow glossary
- snow & land ice data
- special reports
- sponsors of NSIDC
- staff directory
- State of the Cryosphere
- submitting your data

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T

- tools, data : see data tools
- topographic data and digital elevation models

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U

- U.S. Antarctic Data Coordination Center
- users of NSIDC products and services

W

- WDC: World Data Center for Glaciology, Boulder at NSIDC
- "what's new"
- World Data Center for Glaciology, Boulder

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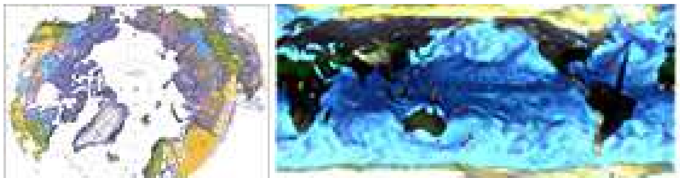

Data Products & Services

The NSIDC DAAC will not be able to process orders for AMSR-E, GLAS, MODIS, or NISE data for an extended period of time on Tuesday, 31 August from 9:00 a.m. to 3:00 p.m. U.S. Mountain Standard Time, because of system maintenance. We apologize for any inconvenience this may cause.

Note: AMSR-E, ICESat/GLAS, MODIS, and NISE data are normally unavailable for ordering on Tuesdays, 9:00 a.m. to 12:00 p.m. U.S. Mountain Standard Time, because of system maintenance.

The National Snow and Ice Data Center offers hundreds of data products and services to researchers, commercial applications users, and others worldwide, most often at no cost, thanks to the generosity of our data providers.

FIND DATA

- **Search Data Sets**
- **Browse Data Set Lists**:

Data Resources

New or First Time User? Please read our introduction to NSIDC data.

Submitting Data to NSIDC? If you would like to make your data available to peers,

DATA NEWS & FEATURES

DATA FEATURES

NSIDC User Board
a forum for users to exchange information and experiences working with NSIDC's data.

More data features >

DATA NEWS

19 July 2004

[Atmosphere](#)
[Biosphere](#)
[Frozen Ground](#)
[Glaciers/Ice Sheets](#)
[Hydrosphere](#)
[Land Surface](#)

[Oceans](#)
[Paleoclimate/Ice Cores](#)
[Spectral/Engineering](#)
[Sea Ice](#)
[Snow and Land Ice](#)

[Data Contributors](#)

[All Data Sets by Title](#)

colleagues, and others via the National Snow and Ice Data Center, please consider submitting data to NSIDC.

Citing NSIDC Data? To give data contributors due credit and help us provide better data related services, please read our request regarding citing NSIDC data.

Vertical Boundary Layer Profiles for Ozone and Meteorological Parameters at Summit, Greenland, 2000: a new data set from the ARCSS Data Coordination Center (ADCC) at NSIDC.

More product news >

Data Centers, Programs, & Projects:

IARC Frozen Ground Data Center [Go!]

AMSR-E Data at NSIDC [Go!]

Help Tips on finding data at NSIDC

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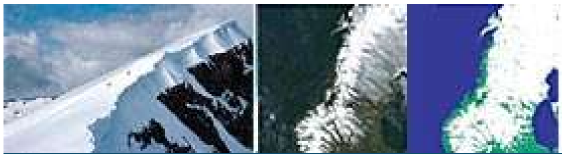

Projects at NSIDC

Data Centers and Programs

IARC Frozen Ground Data Center. The International Arctic Research Center and the National Science Foundation funds the Frozen Ground Data Center at NSIDC, a cooperative project of the World Data Center for Glaciology at Boulder, the International Arctic Research Center (IARC), and the International Permafrost Association (IPA). The Frozen Ground Data Center identifies, archives, documents, and distributes data related to permafrost and seasonally frozen ground.

NASA Distributed Active Archive Center. NSIDC is one of eight Distributed Active Archive Centers (DAACs) that participate in NASA's Earth Observing System Data and Information System (EOSDIS). The DAACs process, archive, document, and distribute data from NASA's past and current Earth science research satellites and field measurement programs.

NOAA at NSIDC. The National Oceanic and Atmospheric Administration (NOAA) provides support for management of NOAA data sets at NSIDC, and has funded many of NSIDC's data rescue activities.

NSF Arctic System Science Data Coordination Center. Funded by the National Science Foundation's Office of Polar Programs, the Arctic System Science (ARCSS) Data Coordination Center at NSIDC is the permanent data archive for all components of the ARCSS Program.

NSF Antarctic Glaciological Data Center. The National Science Foundation's Office of Polar Programs funds the U.S. Antarctic Glaciological Data Center (AGDC) at NSIDC to archive and distribute Antarctic glaciological and cryospheric system data collected by the U.S. Antarctic Program.

NSF U.S. Antarctic Data Coordination Center. The National Science Foundation's Office of Polar Programs funds

Data Projects

Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E)

Cold Land Processes Experiment (CLPX)

Environmental Working Group (EWG)

Greenland Ice Sheet Project 2 (GISP2)

Global Digital Sea Ice Data Bank (GDSIDB)

Global Land Ice Measurements from Space (GLIMS)

Human Dimensions of the Arctic System (HARC)

Ice, Cloud, and land Elevation Satellite/Geoscience Laser Altimeter System (ICESat)

International Ice Charting Working Group (IICWG)

Land/Atmosphere/Ice Interactions (LAII)

Moderate Resolution Imaging Spectroradiometer (MODIS)

NSIDC to function as the U.S. Antarctic Data Coordination Center. The Antarctic Data Coordination Center identifies existing Antarctic data sets, locates points of contact, prepares data descriptions, and coordinates their submittal to the Antarctic Master Directory (AMD) and the Global Change Master Directory (GCMD).

World Data Center for Glaciology, Boulder. The World Data Center for Glaciology, maintained at NSIDC through a cooperative agreement between NOAA and the Cooperative Institute for Research in Environmental Sciences (CIRES), is one of three international World Data Centers focusing on cryospheric and polar processes.

Ocean/Atmosphere/Ice Interactions (OAII)

Program for Arctic Regional Climate Assessment (PARCA)

Paleoenvironmental Arctic Science (PARCS)

Polar Pathfinders

Radarsat Antarctic Mapping Project (RAMP)

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NSIDC Researchers

Researchers at NSIDC investigate the dynamics of Antarctic ice shelves, new techniques for the remote sensing of snow and freeze/thaw cycle of soils, the role of snow in hydrologic modeling, linkages between changes in sea ice extent and weather patterns, large-scale shifts in polar climate, river and lake ice, and the distribution and characteristics of seasonally and permanently frozen ground.

In-house scientific expertise helps NSIDC improve the quality of research data sets and respond quickly to inquiries on snow and ice topics from the general public. Scientists pursue their work as part of the CIRES Cryospheric and Polar Process Division, University of Colorado, Boulder. National agencies fund research through the peer review proposal process. Please direct all requests for information and data products, including general questions about the cryosphere, to NSIDC User Services (nsidc@nsidc.org).

RESEARCHER	RESEARCH SNAPSHOTS
Roger Barry • NSIDC Director • CIRES Fellow • CU Distinguished Professor • CU Geography Faculty	Climate-cryosphere interactions; arctic and mountain climate; climate change; snow and ice data as climate indicators. Current focus on soil temperature trends in Russia. A Regional, Integrated Monitoring System for the Hydrology of the Pan-Arctic Land Mass
Todd Arbetter	Sea ice modeling; polar oceanography and ocean modeling; polar meteorology and atmospheric modeling; coupled regional climate modeling of areas within the Arctic and Antarctic; assimilation of observed sea ice motion in standalone and coupled sea ice models; study of Arctic and Antarctic polynyas using regional climate models

Richard Armstrong

Remote sensing of snow and frozen ground; passive microwave satellite remote sensing, calibration, and validation; physical and mechanical properties of snow; snow avalanches; evaluation of snow cover fluctuations and glacier mass and extent as indicators of climate change; development of scientific data sets to support snow and ice research.

Passive Microwave Snow Cover Algorithm Intercomparison and Validation

Investigation of the Seasonal Freeze/Thaw Cycle of Soils in the GEWEX American Prediction Program Regions

A Regional, Integrated Monitoring System for the Hydrology of the Pan-Arctic Land Mass

Andy Barrett

Western USA water resources; hydrology of mountain and upland drainage basins; use of remotely sensed data in applied hydrologic modeling; hydrologic modeling; hydroclimatology; glaciology; glacier hydrology.

NASA Southwest Regional Earth Science Applications Center

Regional Assessment of Water, Climate and Society in the Interior Western United States -- Development of Operational Hydrologic Forecasting Capabilities

Florence Fetterer

Sea ice, applications-oriented remote sensing, data rescue, data set development. Serves as NSIDC's NOAA liaison and program manager.

Sea Ice Index and Archives

Sea Ice Surface Characteristics from High Resolution Reconnaissance Imagery

Oliver W. Frauenfeld

Cryosphere-climate interactions; large-scale atmospheric circulation response to high-latitude forcing; freeze-thaw cycle in seasonally frozen ground and permafrost regions; active layer processes; Northern Hemisphere circumpolar vortex variability; atmospheric teleconnections; climate change; quantitative methods; ocean-atmosphere interactions.

Jim Maslanik

Sea ice-ocean-atmosphere interactions; arctic regional climatic change; remote sensing of ice, ocean, and land conditions; regional modeling of sea ice and climate; satellite algorithm validation; development of unpiloted aerial vehicles for high-latitude climate research.

Sea Ice Variability in the Beaufort and Chukchi Seas: Processes and Prediction

Improving the Simulation of Sea Ice Lead Conditions and Turbulent Fluxes Using RGPS Products and Merged RADARSAT, AVHRR and MODIS Data

Walt Meier

Remote sensing of sea ice from visible, infrared, and active/passive microwave sensors; focus is on passive-microwave sea ice concentration and sea ice motion products; develops data assimilation methods to combine sea ice observations with sea ice and coupled models.

Thomas H. Painter

Multispectral and hyperspectral remote sensing of snow, spatially distributed snowmelt modeling, measurement and modeling of the directional reflectance of snow, remote sensing of desertification processes, and robotic instrumentation. Current research on remote sensing products for the NASA/NWS Cold Land Processes Experiment and the hydrologic and radiative effects of deposited dust to alpine snowfields.

Multi-Resolution Snow Products for the Hydrologic Sciences

Ted Scambos

Remote sensing of ice sheets, glaciology, Antarctica, global change in the polar regions, extraterrestrial ice, history of the exploration of Antarctica.

Characteristics of Snow Megadunes on the East Antarctic Plateau

Improvement of the Greenland DEM Using Photoclinometry

Greg Scharfen

Remote sensing of snow cover, sea ice and glaciers. Serves as NSIDC's project manager for the MODIS snow and ice products, GLIMS glacier database, and NSF Antarctic data management projects.

Mark Serreze

Large-scale hydroclimatology of the Arctic, including patterns of precipitation and evaporation; variability in the synoptic scale circulation in the Arctic, including characteristics of cyclone development and decay; atmosphere-sea ice interactions; validation of numerical weather prediction output, especially from atmospheric reanalysis products.

A Regional, Integrated Monitoring System for the Hydrology of the

Pan-Arctic Land Mass

Regional Assessment of Water, Climate and Society in the Interior Western United States -- Development of Operational Hydrologic Forecasting Capabilities

Andrew Slater

Land surface modeling, specializing in cold-regions processes such as snow and frozen ground; land-atmosphere interactions; large-scale, high-latitude hydrology; remote sensing of snow; develops data assimilation techniques for land surface and hydrologic models; hydrologic forecasting.

A Land Surface Model Hind-Cast for the Terrestrial Arctic Drainage System

Julienne Stroeve

Remote sensing of snow and ice; optical, thermal and passive microwave remote sensing; radiative transfer modeling; cryosphere-climate interactions; Greenland climate studies; development of scientific data sets for cryospheric research.

Evaluation and Error Assessment of Operational Passive Microwave Sea Ice Algorithms

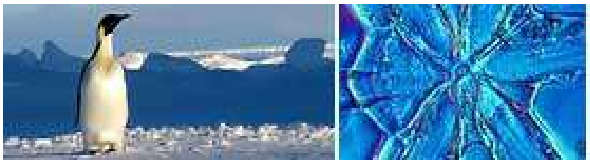
Tingjun Zhang

Seasonally and perennially frozen ground, snow and ice; cryosphere-climate interactions; heat and mass transfer in porous media; numerical modeling of soil freezing and thawing processes, ground thermal regime, lake ice, talik formation under thaw lakes; synoptic-scale snowmelt at high latitudes; application of satellite remote sensing data (passive microwave, SAR, and AVHRR) to study snow, near-surface soil freeze/thaw status, and northern phenomena.

Investigation of the Seasonal Freeze/Thaw Cycle of Soils in the GEWEX American Prediction Program Regions

A Regional, Integrated Monitoring System for the Hydrology of the Pan-Arctic Land Mass

GRADUATE STUDENT	RESEARCH INTEREST	ADVISORS
Anton Seimon	Social and environmental consequences of climate change in mountainous regions. Current work relates rapid ecological response to ongoing deglaciation and anthropogenic factors in high alpine zones of the Peruvian Andes. Previously worked as research meteorologist investigating mesoscale phenomena in extratropical cyclones and lightning in tornadic thunderstorms.	Roger Barry
Eileen McKim	Cryosphere-climate interactions, climate variability/climate change, land surface interactions with the climate system. Current focus on U.S. Western Water Resources; snow-monsoon relationships, variability in the North American Monsoon System.	Roger Barry



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- [Ice Shelves](#)
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- [Sea Ice](#)
- [Snow](#)
- [NSIDC Notes](#)
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19 JUNE 2004

Another Record Minimum for Sea Ice Cover in the Arctic Ocean?

Is the Arctic in for another record low sea ice year? It is starting to look like it.

The recently released June 2004 ice extent and concentration are much lower than normal, indicating that annual minimum ice extent and concentration, which occurs in September, is likely to be well below normal. If so, this would be the third year in a row with substantial below-normal ice conditions in the Arctic, an unprecedented event in the 30+ year record of satellite observations of Arctic sea ice.

[more >>](#)

NSIDC News

26 MAY 2004

"The Day After Tomorrow"

The motion picture *The Day After Tomorrow* may leave many viewers with questions about climate change. In the movie, recent events on Earth s ice sheets and hypothetical future events based on what is known about how climate, oceans, and ice sheets interact, are woven into an exciting but fictitious story about a future climate disaster. The kind of disaster portrayed in the movie is impossible, but the patterns described by the movie have a distant basis in real concepts being discussed by climate scientists, oceanographers, and glaciologists.

[Read NASA's official response to the movie with additional information from NSIDC.](#)

The Cryosphere in the News

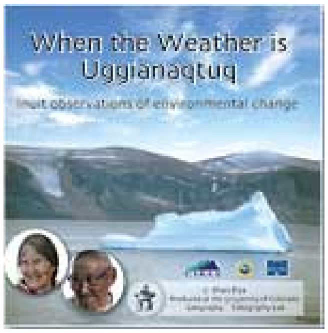
18 AUGUST 2004
"Ongoing warm-up hikes chances of spring floods and shrinking supply of water from snowpack: Ask for a glass of water in a San Francisco restaurant, and you might end up sipping part of a glacier here in Yosemite National Park. ..."([The Sacramento Bee](#))

18 AUGUST 2004
"New proposal would use ocean to store carbon: Scientists from Monterey Bay are investigating a possible remedy for global warming: storing the atmosphere's excess carbon in Earth's hidden closet - the deep sea. ..."([The Sacramento Bee](#))

18 AUGUST 2004
"The big thaw: Retreating glaciers, rising seas, and shrinking lakes are

01 MAY 2004

When the Weather is Uggianaqtuq: Inuit Observations of Environmental Change



NSIDC and the Arctic System Science (ARCSS) Data Coordination Center have released a new multi-media, interactive CD, entitled "When the Weather is Uggianaqtuq: Inuit Observations of Environmental Change." Uggianaqtuq (pronounced OOG-gi-a-nak-took) is a North Baffin Inuktitut word that means to behave unexpectedly, or in an unfamiliar way. From the perspective of many Inuit in the Arctic, the weather has been uggianaqtuq in recent years. In this CD, Inuit from two communities in Nunavut, Canada (Baker Lake and Clyde River), share their observations and perspectives on recent environmental changes. Maps, text, photos, video and music are integrated to help illustrate the changes Inuit have observed in their environment and the impacts on their livelihoods.

The CD, authored by Shari Fox Gearheard, is available free of charge. To read more about the project or to order a copy of the CD, please visit the product web site.

21 APRIL 2004

AMSR-E soil moisture data from NSIDC used to study March 2004 flooding

Spatial extent of soil moisture

Steven Chan of NASA's Jet Propulsion Laboratory used AMSR-E soil moisture data available from NSIDC to quantify the extent of flooding after a large-scale thunderstorm swept through the midwestern U.S. in March 2004. Chan created maps that show a gradual buildup and reduction of soil wetness as the storm moved through the region. Read more about this study here.

some of the global changes already under way. ..."(NationalGeographic.com)

18 AUGUST 2004
"Ice yields ancient 'plant matter': Scientists drilling ice cores in Greenland have recovered what appear to be plant remains from nearly 3km (two miles) below the surface. ..."(BBC News)

10 AUGUST 2004
"Team will brave ice floes to test climate change: An international team of scientists left from Norway over the weekend on an expedition to see if the Earth is slowly headed for another ice age or will keep getting warmer. ..."(International Herald Tribune)

6 AUGUST 2004
"Tracking climate change through Baffin's foxes: Researchers have discovered the value of foxes as early indicators of the impact of climate change in Nunavut. ..."(Nunatsiaq News)

6 AUGUST 2004
"Scientists alarmed at increase in melt rate of ice: Greenland's cover of ice is melting ten times quicker than previously thought, an increase that could lead to floods across the world, scientists have found. ..."(Scotsman.com)

6 AUGUST 2004
"Mont Blanc is shrinking, say experts: Mont Blanc may still be Europe's highest mountain, but it is not quite as high as it was last year. ..."(Guardian Unlimited)

4 AUGUST 2004
"Retreating glaciers spur Alaskan earthquakes: In a new study, NASA and United States Geological Survey (USGS) scientists found that retreating glaciers in southern Alaska may be opening the way for future earthquakes. ..."(Goddard Space Flight Center)

4 AUGUST 2004
"A giant ecosystem that has functioned for millions of years has

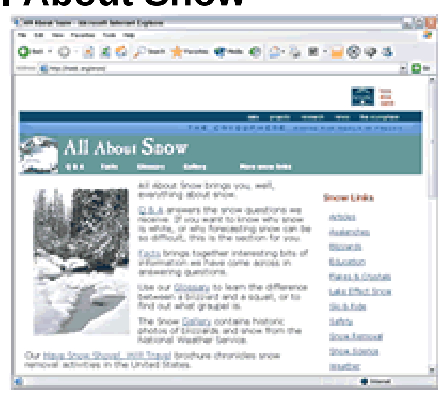
04 MARCH 2004

NSIDC Director Roger Barry named Distinguished Professor

Roger Barry, director of the National Snow and Ice Data Center for the past 27 years, was named Distinguished Professor by the University of Colorado Board of Regents. The designation of distinguished professor is bestowed on members of the university faculty "who have distinguished themselves as exemplary teachers, scholars and public servants and who are individuals having extraordinary international importance and recognition." President Elizabeth Hoffman and Chancellor Richard Byyny praised Barry's work, recognizing his research in the climates of arctic and alpine environments as well as his contributions to NSIDC. Read more about Barry's accomplishments in the Colorado Daily, the University of Colorado press release, and Our Director.

05 FEBRUARY 2004

USA Today's Web Guide Features NSIDC's "All About Snow"



NSIDC's "All About Snow" section of its newly redesigned web site was featured as a "Hot Site" in USA Today's Web Guide. The site features quick facts about snow, answers to frequently asked questions, a gallery of historic photographs, and various related links.

24 JANUARY 2004

Arctic Perspectives on the Climate Change Debate

begun to break down: They are disaster zones: professional ornithologists who have spent their careers monitoring the teeming, screaming bird life of Orkney and Shetland have never seen anything like it. ..."(Independent News)

3 AUGUST 2004
"Polar bears roam Arctic ice on borrowed time: There are today nearly as many polar bears as people in the Norwegian archipelago of Svalbard, a mere 1,000 kilometers (620 miles) from the North Pole, but experts fear that balance is about to shift as the white king of the ice roams steadily towards extinction. ..."(Terra Daily)

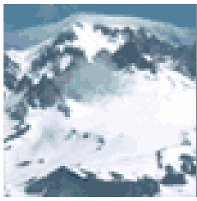
On 23 January 2004, Dr. Mark Serreze, Research Scientist at NSIDC/CIRES, presented a Cryospheric and Polar Processes Division Seminar/coffee.

Eclipse Sound, the Arctic

The seminar examined the role of human impacts and natural variability affecting climate, ice cover, vegetation, and oceanic and atmospheric circulation patterns in the Arctic region. For more information, please see the full event abstract.

See Also
NSIDC News Archives

The National Snow and Ice Data Center (NSIDC)
Supporting Cryospheric Research Since 1976
CIRES, 449 UCB University of Colorado Boulder, CO 80309-0449
NSIDC privacy policy



All About Snow

More Snow Resources

NSIDC has collected a variety of links on snow-related subjects. If you did not find an answer to your question in All About Snow, you might find what you need on one of these pages. **For snow site links, select a category from the list on the right.** We hope that you will find these links useful.

You might also be interested in NSIDC's Avalanche Awareness or Blizzards of 1996 sites.

The Snow Booklet

For more information, try The Snow Booklet: A Guide to the Science, Climatology, and Measurement of Snow in the United States by Nolan J. Doesken and Arthur Judson (1996, ISBN #0-9651056-2-8) from the Colorado Climate Center:

Colorado Climate Center
Atmospheric Science Department
Colorado State University
Fort Collins, CO

Snow Links

- Articles
- Avalanches
- Blizzards
- Education
- Flakes & Crystals
- Lake Effect Snow
- Ski & Ride
- Safety
- Snow Removal
- Snow Science
- Weather

For Scientists and Researchers

- Snow Data Sites
- Snow Science Sites

See Also

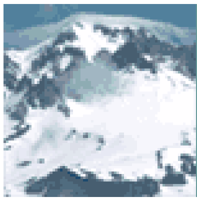
- Avalanche Awareness

[redacted] 80523-1371

[Blizzards of 1996](#)

[Have Snow Shovel, Will Travel](#)

[Snow in the News](#)



Snow Gallery

Blizzards

The Great Blizzard of March 12, 1888. New York, New York. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection.) Larger version (43k).

Snow shovelers in Flushing, New York, during the Great Blizzard of March 12, 1888. New York, New York. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection.) Larger version (32k).

Photograph of a horse drawn sleigh taken on March 18, 1888, during the Great Blizzard. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection.) Larger version (36k).

Cleared train tracks in the Sierra Nevada at Blue Canyon, California, after a snow storm in 1917. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection. Photograph originally published in "Monthly Weather Review," October 1919, p. 698.) Larger version (36k).

Cleared train tracks in the Sierra Nevada at Emigrant Gap, California, after a snow storm in 1917. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection. Photograph originally published in "Monthly Weather Review," October 1919, p. 698.) Larger version (36k).

Paradise Inn, Mount Rainier, Washington. During the winter of 1916-1917, 789.5 inches of snow fell at Paradise Inn. When this photo was taken, in March 1917, the snow was 27 feet deep. (Source: NOAA/Department of Commerce. Courtesy of Historic National Weather Service Collection. Photograph originally published in "Monthly Weather Review," July 1918, p. 330.) Larger version (35k).

An ice storm in Rhode Island, December 1, 1921. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection. Photograph originally published in "The Realm of the Air" by Charles F. Talman, 1931.) Larger version (46k).

A young steer after a blizzard, March 4, 1966. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection.) Larger version (35k).

A man stands near a utility pole in North Dakota, March 9, 1966. A spring blizzard produced snow so deep that it nearly buried the utility poles. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection.) Larger version (33k).

An aerial view of an expressway in Chicago, paralyzed after a blizzard, January 26-27, 1967. (Source: NOAA/Department of Commerce. Courtesy of the Historical National Weather Service Collection.) Larger version (44k).

Even states in the southern part of the United States can get significant amounts of snow. This photo was taken in Bull Shoals, Arkansas, after the Blizzard of '93. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection. Photograph by Elizabeth A. Hobbs.) Larger version (40k).

Power lines sag after a heavy ice storm. No date. (Source: NOAA/Department of Commerce. Courtesy of the Historic National Weather Service Collection.) Larger version (35k).

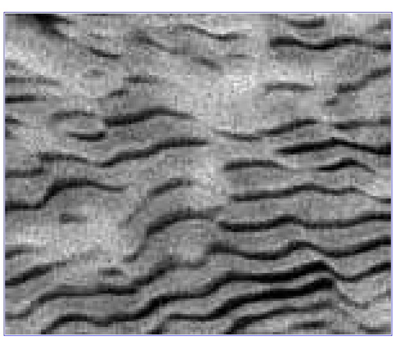
Snow Phenomena and Formations

Cold air and steam from low grade geothermal springs make heavy frost on the trees in this photograph taken at the Spring Inn resort in Pagosa Springs, Colorado on February 1, 1998. A travertine (layered calcium carbonate) cone deposit is on the right. (Courtesy of the National Renewable Energy Laboratory and the Department of Energy. Photograph by Warren Gretz.) Larger version (33k).

Sastrugi at South Pole Station, Antarctica. Sastrugi, or wind sculpted snow, are ridges formed when wind erodes and drifts the snow. No date. (Source: NOAA/Department of Commerce. Courtesy of Mr. Fred Walton, NOAA Corps Collection.) Larger version (33k).

Sastrugi at South Pole Station, Antarctica. Sastrugi, or wind sculpted snow, are ridges formed when wind erodes and drifts the snow. No date. (Source: NOAA/Department of Commerce. Courtesy of Mr. Fred Walton, NOAA Corps Collection.) Larger version (33k).

Sastrugi snow formation in Colorado. Sastrugi are ridges of snow formed when wind erodes and drifts the snow. (Photograph courtesy of Ken Knowles, National Snow and Ice Data Center, University of Colorado, Boulder.) Larger version (30k).



Extensive snow dunes wrinkle the surface of large parts of East and West Antarctica. The dunes are up to 100 kilometers long and separated by 2 to 4 kilometers, but the height is only a few meters. Comparison of modern satellite images with pictures acquired four decades earlier shows that the dunes are nearly motionless. The dunes are unique in that they appear not to be formed by normal wind depositon, but rather by ablation due to wave patterns set up in katabatic winds. The linear pattern is due to backscatter variations associated with grain-size changes across dunes. Larger version (38k).

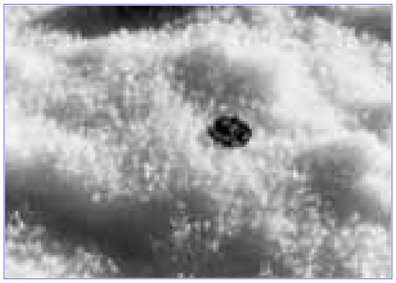
Heavy winds and blowing snow wreak havoc on traffic and roads. A truck with a snow plow attachment clears a road in this photograph from November 10, 1998. (Courtesy of the National Renewable Energy Laboratory and the Department of Energy. Photograph by David Parsons.) Larger version (32k).

A district heating system keeps a sidewalk dry after a snowfall, unlike the sidewalk beyond, which is not heated by the system. In Klamath Falls, Oregon, a geothermal district heating system keeps the sidewalks clear and dry at the Basin Transit station after a snowfall. The trees are protected with Styrofoam insulation to keep them from budding in the winter during system operation. The district heating system melts snow on more than 50,000 square feet of sidewalks and crosswalks. Snowmelt tubing in slurry was installed under the sidewalks in 1995 as part of the city's district heating system, which was constructed in 1981 to heat 14 government buildings, including the county museum, fire station, post office, city hall, library, courthouse, and jail. The system has now expanded to include non-government buildings, such as churches and small businesses, for a total of around 26 buildings. No date. (Courtesy of the National Renewable Energy Laboratory and the Department of Energy. Photograph by the Geo-Heat Center.) Larger version (35k).

Avalanche related photographs

An avalanche in motion. (Photograph courtesy of Richard Armstrong, National Snow and Ice Data Center.) Larger version (30k).

The three parts of an avalanche path: starting zone, track, and runout zone. (Photograph courtesy of Betsy Armstrong.) Larger version (37k).



A new layer of surface hoar on the snow. Note the quarter for scale. (Photograph courtesy of K. Williams.) Larger version (33k).

Wind scouring snow off of the windward side of the peak and depositing it on the leeward side. (Photograph courtesy of Richard Armstrong.) Larger version (28k).

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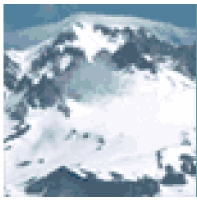
THE CRYOSPHERE WHERE THE WORLD IS FROZEN



All About Snow

Q & A Facts Glossary Gallery More snow links

Questions and Answers about Snow

How big can snowflakes get?

Snowflakes are agglomerates of many snow crystals. Most snowflakes are less than one-half inch across. Under certain conditions, usually requiring near-freezing temperatures, light winds, and unstable, convective atmospheric conditions, much larger and irregular flakes close to two inches across in the longest dimension can form. No routine measure of snowflake dimensions are taken, so the exact answer is not known.

See also the NOAA Question of the Month: How do snow flakes form into so many uniquely different shapes?

Why is snow white?

Visible sunlight is white. Most natural materials absorb some sunlight which gives them their color. Snow, however, reflects most of the sunlight. The complex structure of snow crystals results in countless tiny surfaces from which visible light is efficiently reflected. What little sunlight is absorbed by snow is absorbed uniformly over the wavelengths of visible light thus giving snow its white appearance.

What causes the blue color that sometimes appears in snow and ice?

Generally, snow and ice present us with a uniformly white face. This is because most all of the visible light striking the snow or ice surface is reflected back without any particular preference for a single color within the visible spectrum. The situation is different for that portion of the light which is not reflected but penetrates or is transmitted into the snow. As this light travels into the snow or ice, the ice grains scatter a large amount of light. If the light is to travel over any distance it must survive many such scattering events, that is it must keep scattering and not be absorbed. The observer sees the light coming back from the near surface layers (mm to cm) after it has been scattered or bounced off other snow grains only a few times and it still appears white. However, the absorption is preferential. More red light is absorbed compared to blue. Not much more, but enough that over a considerable distance, say a meter or more, photons emerging from the snow layer tend to be made up of more blue light than red light. Typical examples are poking a hole in the snow and looking down into the hole to see blue light or the blue color associated with the depths of crevasses in glaciers. In each case the blue light is the product of a relatively long travel path through the snow or ice. So the spectral selection is related to absorption, and not reflection as is sometimes thought. In simplest of terms, think of the ice or snow layer as a filter. If it is only a centimeter thick, all the light makes it through, but if it is a meter thick, mostly blue light makes it through.

Source: NSIDC researcher, Richard Armstrong. For a complete treatment of this subject, see Bohren, C. F. 1983. Colors of snow, frozen waterfalls, and icebergs. *J. Opt. Soc. Am.* 73(12):1646-1652.

Is it ever too cold to snow?

No, it can snow even at incredibly cold temperatures as long as there is some source of moisture and some way to lift or cool the air. It is true, however, that most heavy snowfalls occur with relatively warm air temperatures near the ground - typically 15°F or warmer since air can hold more water vapor at warmer temperatures.

Does snow always get fluffier as temperatures get colder?

No. Studies in the Rocky Mountains have shown that the fluffiest, lowest density (0.01 - 0.05) snows typically fall with light winds and temperatures near 15°F. At colder temperatures, the crystal structure and size change. At very cold temperatures (near and below 0°F) crystals tend to be smaller so that they pack more closely together as they accumulate producing snow that may have a density (water-to-snow ratio) of 0.10 or more.

Is it true that there is one inch of water in every ten inches of snow that falls?

The water content of snow is more variable than most people realize. While many snows that fall at temperatures close to 32oF and snows accompanied by strong winds do contain approximately one inch of water per ten inches of snowfall, the ratio is not generally accurate. Ten inches of fresh snow can contain as little as 0.10 inches of water up to 4 inches depending on crystal structure, wind speed, temperature, and other factors. The majority of U.S. snows fall with a water-to-snow ratio of between 0.04 and 0.10.

Why is snow a good insulator?

Fresh, undisturbed snow is composed of a high percentage of air trapped among the lattice structure of the accumulated snow crystals. Since the air can barely move, heat transfer is greatly reduced. Fresh, uncompacted snow typically is 90-95 percent trapped air.

How much snow falls where I live?

Sioux City, Iowa receives approximately 30 inches in an average year with roughly six inches falling each month from December through March. To check snowfall amounts for your area of the United States, see the average snowfall total table for hundreds of American cities and towns (provided by the National Climatic Data Center).

How much snow has fallen in a single day? Seven days? A month?

For snowfall amounts in the United States, see the National Snowfall and Snow Depth Extremes Table provided by the National Climatic Data Center.

Is snow edible?

Clean snow is certainly edible. Snow in urban areas may contain pollutants that one should not eat but they would probably be in such low concentrations that it might not matter. Still, eating snow should be restricted to "wilderness" areas. Sometimes snow contains algae which gives it a red color. This snow can be eaten and some say it actually tastes "good" but we have never tried it.

Why is snow colder in deeper spots?	Snow is not necessarily colder in deeper spots. The temperature at the surface of the snow is controlled by the air temperature. The colder the air above the colder will be the snow layers near the surface, say within the top 12 to 18 inches. The snow near the ground in deeper snowpacks however is warmer because it is close to the warm ground. The ground is warm because the heat stored in the ground over the summer is slow to leave the ground because snow is a good "insulator," just like the insulation in the ceiling of your house, and thus slows the flow of heat from the warm ground to the cold air above.
Why is snow deep in spots and not others?	At the local scale, say from your backyard to the size of your neighborhood or town, this would be mainly due to wind during and after the storm and melting due to sun after the storm. At the larger scale, say the state of MN, it would also depend on the storm track -- were you in the middle of the storm track or at the edges where less snow fell?
Why do more icicles form on the south sides of buildings?	Icicles form as the result of cycles of melting and freezing. Typically this cycle will occur more often on the south sides of buildings, melting in the day and freezing at night, whereas on the north sides, without the benefit of the warmth of the sun, melting does not occur as often.
What is a Nor'easter?	According to the Weather Glossary at weather.com, a Nor'easter is a cyclonic storm that occurs off the east coast of North America is notorious for producing heavy snow, rain, and waves that crash onto Atlantic beaches. For a more detailed answer to this question, see the NOAA Question of the Month: What is a Nor'easter or Northeast Winter Storm?.
Why do weather forecasters seem to have so much trouble forecasting snow?	Snow forecasts are better than they used to be and they continue to improve, but snow forecasting remains one of the more difficult challenges for meteorologists. One reason is that for many of the more intense snows, the heaviest snow amounts fall in surprisingly narrow bands that are on a smaller scale than observing networks and forecast zones. Also, extremely small temperature differences that define the boundary line between rain and snow make night-and-day differences in snow forecasts. This is part of the fun and frustration that makes snow forecasting so interesting.

What is a winter weather watch? warning? advisory?

NOAA's National Weather Service issues Winter Storm Outlooks when forecasters believe there is a good chance of a major winter storm. A Winter Storm Watch is issued to alert the public to the possibility of a blizzard, heavy snow, heavy freezing rain or heavy sleet. Winter Storm Warnings are issued when a hazardous winter weather event is imminent or occurring, and is considered a threat to life and property. Finally, a Winter Weather Advisory is issued for accumulations of snow, freezing rain, freezing drizzle and sleet that will cause significant inconveniences and, if caution is not exercised, could lead to life-threatening situations.

For a more detailed answer to this question, see the NOAA Question of the Month: Winter Weather Watches, Warnings and Advisories - What do they all mean?

What is the difference between snow, sleet, hail, and other forms of precipitation?

For definitions of sleet, snow, snowflakes, snow flurries, snow grains, snow pellets, hail, soft hail, and other forms of precipitation, see the precipitation definitions in USA TODAY's Weather Book.

Can there be thunder and lightning with a snow storm?

Thunder and lightning can be associated with snowstorms but they are rare and occur more often near the coast.

For a more detailed answer, see The New York Times Learning Network's Thunder Snow. For a more technical explanation, see the NOAA/National Severe Storms Laboratory's paper titled, Thunderstorms observed at surface temperatures below freezing across North America.

Does snow change how sound waves travel?

Yes, when the ground has a thick layer of fresh, fluffy snow, sound waves are readily absorbed at the surface of the snow. However, the snow surface can become smooth and hard as it ages or if there have been strong winds. Then the snow surface will actually help reflect sound waves. Sounds may seem clearer and travel farther under these circumstances.

Why does snow crunch when you step on it? At what temperature does it crunch?

Snow is made of ice crystals. Ice crystals have six points. One snowflake can consist of multiple crystals. There are gaps between the points of a crystal that are empty, except for air. When snow falls to the ground, air is trapped inside of that layer of snow. You have probably noticed that when snow is stepped on, it gets compressed. The air gets pushed out of the snow. The sound you hear could be the sound of the ice crystals as they break. Try it with ice cubes. They make a crunching sound when they are broken.

Also, on a sunny day, the surface layer of snow can melt, due to thermal heating. When the sun goes down and temperatures drop, that top layer refreezes into a thin crust of ice. If you step on it, you are breaking that top crust, resulting in a "crunching" sound.

The crunching sound is less related to temperature and more related to the structure of the snow. The older the snow, the more compacted and icy it becomes.

Source: NSIDC researcher, Richard Armstrong, April 2002

What is lake effect snow?

According to the Weather Glossary at weather.com, lake effect snow is "snow showers that are created when cold dry air passes over a large warmer lake, such as one of the Great Lakes, and picks up moisture and heat."

For a more detailed answer to this question, see the NOAA Question of the Month: What is Lake Effect Snow?

See also NSIDC's list of lake effect snow sites.

Is snow a mineral?

Snow is crystals of frozen water, i.e., ice. The definition of a mineral that I studied is this:

> A mineral is a naturally occurring homogeneous solid, inorganically formed, with a definite chemical composition and an ordered atomic arrangement.

Based on that definition, I'm sure you can determine that ice is a mineral. Ice has a definite chemical composition (H20). It is naturally occuring given a temperature below 0 deg C. It is homogeneous (of one material), formed inorganically, and has an ordered atomic structure (hydrogen and oxygen atoms bonding in a specific manner).

Source: Betsy Sheffield, NSIDC User Services, November 2002

Can it snow in warmer weather? Is snow dependent on temperature or dew point?

"*I live in Michigan and the today's weather forecast calls for 33 degrees and snow. How does it snow in warmer weather, above freezing? Is snow dependent on temperature or dew point?*"

Temperatures do need to be at or below freezing (0 Celsius or 32 Fahrenheit) for snow to form. It is possible for this forecast, however, that temperatures in the atmosphere, where snow forms, were colder than at the surface. It is then possible for snow to fall when surface temperature is above freezing, although the snow will probably be relatively moist, and it may melt. Alternatively, the snow will bring cooler temperatures to the surface, and it will accumulate.

Source: Kate Daniels, NSIDC User Services, February 2003

Before You Send Your Email

E-mail Search Home

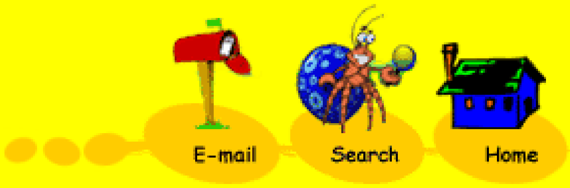
Before you send your E-mail, please note:

- FEMA materials or publications cannot be requested with an E-mail.
- FEMA cannot provide individualized homework help.
- Do you want a hurricane named after you?
- Do you want to know more about earthquakes?
- Do you want to know more about tornadoes?

Do you want to give us feedback on FEMA for Kids or submit a comment?

FEMA for Kids
Federal Emergency Management Agency

Search



Herman's Beach Search and Help Page

Type a keyword, and I'll find what you're looking for: GO!

FEMA for Kids

Federal Emergency Management Agency

Shake with the Quake

Once upon a time there was a little boy named Leonard. One night, as he was lying in his bed, his whole room began to shake. And then it rattled. And then it started to roll.

This experience scared Leonard very much because he had never been in an earthquake before. And even after the earthquake had stopped he was still very afraid because he wasn't sure what he was supposed to do.

Leonard thought tremendously hard and tried to imagine what he could do. But he just couldn't quite think of it. He thought so hard that he began to get extremely tired. He got so tired that he could hardly keep his head off the pillow. And finally he fell asleep.

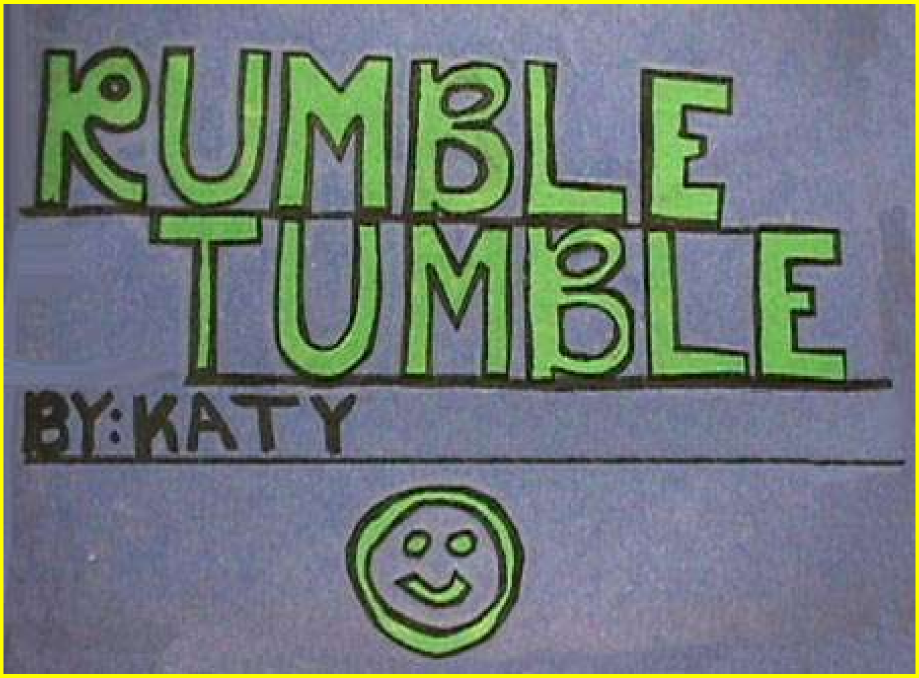
That night, in his dreams, Leonard imagined that he was back in that earthquake. But this time he wasn't as scared because he knew what to do! Three experts from the Institute of Emergency Preparedness had come into the bedroom of his dreams and had taught Leonard what to do whenever there is an earthquake. They were Leonard's own very special "Earthquake Buddies." This is what they taught him:

Next Page »

FEMA for Kids

Federal Emergency Management Agency

Rumble Tumble By Katy



Caption: Rumble Tumble By Katy

Next »

More Disaster Stories By Kids

Earthquakes

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The Northridge Earthquake

On January 17, 1994, the people around Northridge, California, were awakened early in the morning by a large earthquake. The quake struck at 4:31 a.m. and had a magnitude of 6.7, according to the U.S. Geological Survey. The fault responsible for the earthquake ran underneath the San Fernando Valley and had been unknown before the Northridge Earthquake.

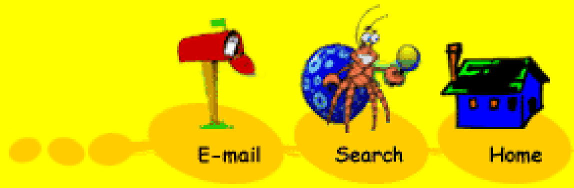
The quake was felt for 2,000 square miles in Los Angeles, Orange and Ventura counties. There were nearly 15,000 aftershocks following the main earthquake. The earthquake killed 57 people and injured nearly 12,000 people. The damage was extensive, damaging about 100,000 houses and businesses. Parking garages collaped and some apartment buildings were reduced to rubble. The earthquake caused more than $40 billion in damage.

The area was declared a federal disaster by President Clinton and hundreds of workers from FEMA were deployed to Southern California to help the communities there recover. More than 600,000 individuals applied for state and federal disaster assistance, and FEMA spent millions of federal money helping the area recover.

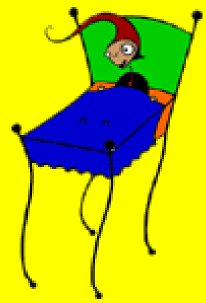
The Northridge Earthquake was the largest earthquake to hit a Southern Californian city since 1971. It was the 11th largest earthquake to be recorded in California since 1769.

Pictures from Northridge Earthquake

Earthquakes



Earthquakes: Home Hazards Hunt



- China cabinet (Should be attached to wall studs)
- Tall knickknack shelves (Should be attached to wall studs)
- Bookshelves (Should be attached to wall studs)
- Heavy hanging plant over a place where people sit (should be light, unbreakable pot and make sure all plants hang from ceiling studs)
- A mirror on the wall (Make sure it is well fastened to the wall)
- Heavy objects on wall shelves (should be moved to bottom shelves or secured)
- Unsecured TV on a rolling cart (Make sure cart wheels are blocked so TV can't roll)
- Bed by a big window (Bed should be moved away)
- Heavy picture above a bed (Bed or picture should be moved)
- A hanging light above a bed (Light should be secured with extra wire or chain, or the bed should be moved.)
- Cabinet doors not fastened to stay closed (Install latches)
- Unattached water heater (Attach water heater to the wall studs)
- Gas stove with rigid feed line (Replace gas line with flexible connectors)
- Heavy wall clock (Attach to wall studs)
- Chimney (Brace outside chimney to the house)
- House not bolted to the foundation. (Foundation should be bolted)

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Hazards

Informing The Public About Hazards

The Six-Year List of Names For Eastern Pacific Tropical Storms

2001	2002	2003	2004	2005	2006
Adolph	Alma	Andres	Agatha	Adrian	Aletta
Barbara	Boris	Blanca	Blas	Beatriz	Bud
Cosme	Cristina	Carlos	Celia	Calvin	Carlotta
Dalila	Douglas	Dolores	Darby	Dora	Daniel
Erick	Elida	Enrique	Estelle	Eugene	Emilia
Flossie	Fausto	Felicia	Frank	Fernanda	Fabio
Gil	Genevieve	Guillermo	Georgette	Greg	Gilma
Henriette	Hernan	Hilda	Howard	Hilary	Hector
Ivo	Iselle	Ignacio	Isis	Irwin	Ileana
Juliette	Julio	Jimena	Javier	Jova	John
Kiko	Kenna	Kevin	Kay	Kenneth	Kristy
Lorena	Lowell	Linda	Lester	Lidia	Lane
Manuel	Marie	Marty	Madeline	Max	Miriam
Narda	Norbert	Nora	Newton	Norma	Norman
Octave	Odile	Olaf	Orlene	Otis	Olivia
Priscilla	Polo	Patricia	Paine	Pilar	Paul
Raymond	Rachel	Rick	Roslyn	Ramon	Rosa
Sonia	Simon	Sandra	Seymour	Selma	Sergio
Tico	Trudy	Terry	Tina	Todd	Tara
Velma	Vance	Vivian	Virgil	Veronica	Vicente
Wallis	Winne	Waldo	Winifred	Wiley	Willa
Xina	Xavier	Xina	Xavier	Xina	Xavier
York	Yolanda	York	Yolanda	York	Yolanda
Zelda	Zeke	Zelda	Zeke	Zelda	Zeke

Last Updated: Tuesday, 11-Feb-2003 08:52:08 EST

Earthquakes

E-mail Search Home

History of Big Earthquakes

Northridge, California (20 miles from Los Angeles)
January 17, 1994
4:31 a.m.
Magnitude: 6.7
Deaths: 57
Injuries: 9,000
Property Damage: $15 billion

Loma Prieta Earthquake (south of San Francisco)
October 17, 1989
5:04 p.m.
Magnitude: 6.9
Length of time: 15 seconds
Deaths: 62
Injuries: 3,757
Property Damage: More than $6 billion

Coalinga, CA
May 2, 1983
Magnitude: 6.4
Deaths: 0
Injuries: 47
Property damage: $31 million

San Francisco, CA
April 18, 1906
5:12 a.m.
Magnitude: 8.25
Length of time: 40 seconds
Deaths: 700 to 2,500 people
Note: The "Great San Francisco Earthquake" is one of the strongest ever recorded in North America. Much of the city was destroyed by the strong shaking, which toppled buildings, and by the fires that followed.

Information courtesy of the U.S. Geological Survey

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Earthquakes

Tasty Quake Activity

Sometimes it’s hard to understand how the earth can move, and why earthquakes damage buildings. This activity will show you how waves will travel to damage buildings. Afterward, you can have dessert!

Materials you will need:
One metal pan of prepared gelatin dessert (recipe below)
Sugar cubes or dominoes
Plastic wrap
Cups and spoons for serving and eating dessert

Ask your parent or another adult to help with this recipe:

Recipe for gelatin dessert:
Two (6 oz) boxes of red or purple gelatin dessert
Two one-serving envelopes of unflavored gelatin
Four cups of boiling water
Four cups of cold water
One 9 X 12 METAL baking pan

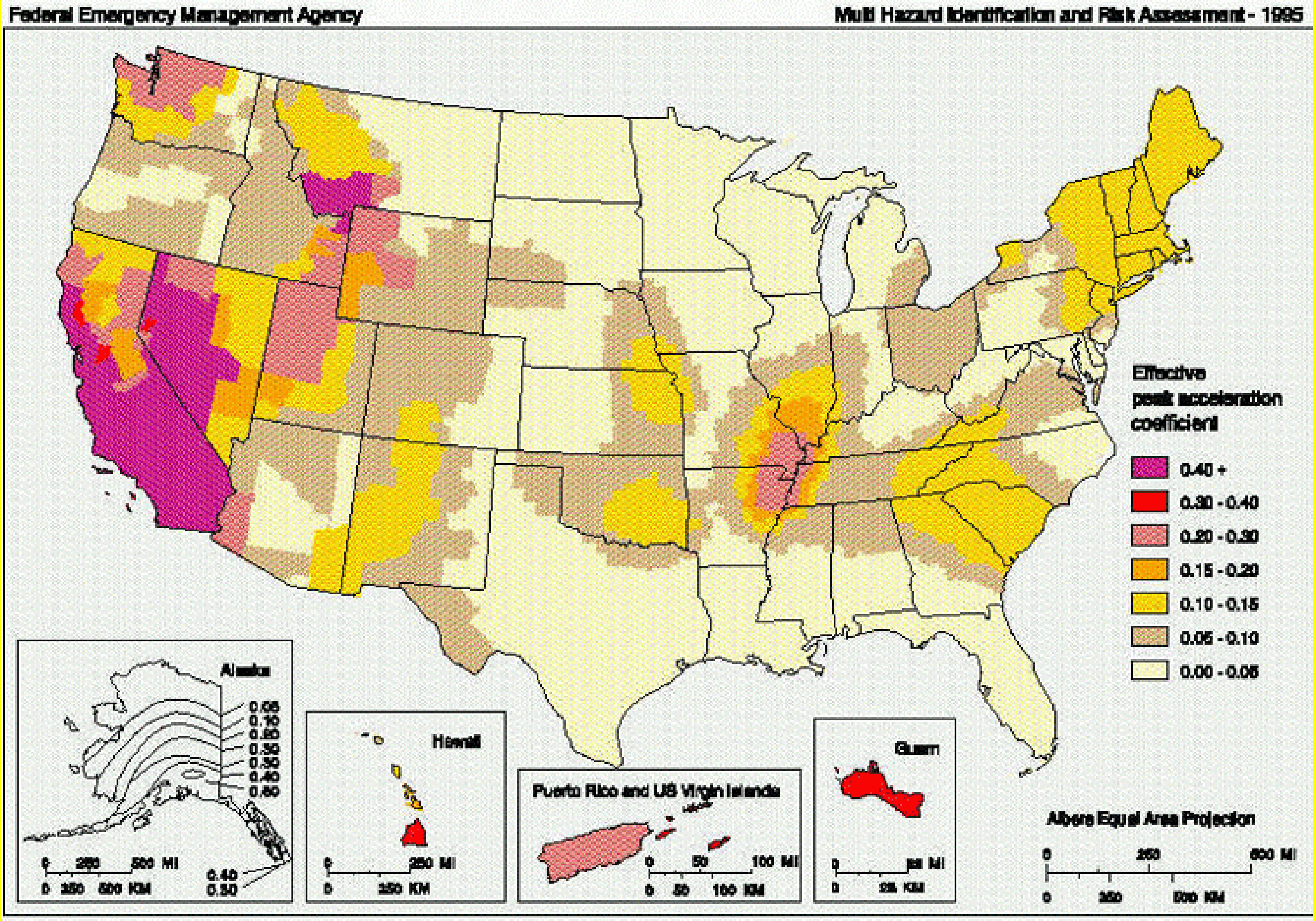
Empty the gelatin dessert and the unflavored gelatin into the baking pan. Add the boiling water and stir until all the powder is dissolved. Add the cold water and mix. Chill in the refrigerator for at least three hours or until set.

When rocks break in the earth’s crust they release energy in the form of waves -- waves that can go through rock and dirt. Gently tap the side of the gelatin pan. You will see waves traveling through the gelatin. This is what an earthquake wave is like when it goes through the earth. Tap the pan harder and see how the waves become bigger.

Now cover the top of the gelatin with plastic wrap (make sure the wrap is right on top and touching the gelatin). Use sugar cubes or dominoes to make "buildings" on the gelatin. What do you think will happen when you tap on the pan to cause "earthquake" waves through the gelatin? Try it. What happened? Make the buildings again and tap the pan harder or softer than the first time. Did something different happen? You can do this over and over. When you're done, take off the plastic wrap and have a gelatin snack!

Earthquakes

Earthquake Risk States



Map 16-1 Spatial variation in the effective peak acceleration coefficient (A_a) for the United States.
Data not available for American Samoa
(Source: Map 1 in 1994 edition of the NEHRP Recommended Provisions)

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Disaster Math

A small earthquake hit Northern California on a Tuesday afternoon. It was felt by people in three cities: Los Manos (population 3,482), Mount Good (population 4,210) and Meganville (872). How many people felt the earthquake?

- ○ 5,684 people
- ○ 8,564 people
- ○ 8,654 people
- ○ 8,546 people

The news said that Bigburg also felt the quake. Its population is 2,998. Now how many people felt the quake?

- ○ 11,562 people
- ○ 10,690 people
- ○ 10,989 people
- ○ 7,773 people

Suppose that it takes two straps each 25 inches long to strap a water heater to the wall to keep it from falling over during an earthquake. There are 420 homes in Los Manos. If every single home in Los Manos strapped their water heater to the wall, how many inches of strap would it take?

- ○ 1,200 inches
- ○ 50 inches
- ○ 420 inches
- ○ 21,000 inches

If you convert those inches into feet, how many feet would it take?

- ○ 12 feet
- ○ 21,012 feet
- ○ 1,750 feet
- ○ 252,000 feet

Pretend that in the first earthquake 10 homes were slightly damaged; in the second 50 homes were slightly damaged and in the third earthquake 30 homes were slightly damaged. What is the average number of homes damaged in the earthquakes?

- ○ 11
- ○ 30
- ○ 35

Get My Score

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Intensity Scales

- Hurricanes - The Saffir Simpson Scale
- Tornadoes - The Fujita Scale
- Earthquakes - The Modified Mercalli Scale & The Richter Scale
- Volcanic Eruptions - The Volcanic Explosivity Index

Hurricanes - The Saffir Simpson Scale

Category	Category Description	Level Of Damage
1	Wind Speed: 74 - 95 MPH Storm Surge: 4 - 5 Feet Above Normal	Primary damaged to unanchored mobile homes, shrubbery, and trees. Some coastal road flooding and minor pier damage. Little damage to building structures.
2	Wind Speed: 96 - 110 MPH Storm Surge: 6 - 8 Feet Above Normal	Considerable damage to mobile homes, piers, and vegetation. Coastal and low-lying escape routes flood 2 - 4 hours before arrival of hurricane center. Buildings sustaiin roofing material, door, and window damage. Small craft in unprotected moorings break moorings.
3	Wind Speed: 111 - 130 MPH Storm Surge: 9 - 12 Feet Above Normal	Mobile homes destroyed. Some structural damage to small homes and utility buildings. Flooding near coast destroys smaller structures; larger structures damaged by floating debris. Terrain continously lower than 5 feet. ASL may be flooded up to 6 miles inland.
4	Wind Speed: 131 - 155 MPH Storm Surge: 13 - 18 Feet Above Normal	Extensive curtainwall failures with some complete roof structure failture on small residences. Major erosion of beaches. Major damage to lower floors of structures near the shore. Terrain continously lower than 10 feet. ASL may flood (and require mass evacuations) up to 6 miles inland.
5	Wind Speed: Over 155 MPH Storm Surge: Over 18 Feet Above Normal	Complete road failure on many homes and industrial buildings. Some complete building failures. Major damage to lower floors of all structures located less than 15 feet ASL and within 500 yards of the shoreline. Massive evacuation of low ground residential areas may be required.

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Tornadoes - The Fujita Scale

Category	Category Description	Level Of Damage
F-0	Gale Tornado 40 - 72 MPH	Chimneys damaged; branches broken off trees; shallow-rooted trees uprooted; sign boards damaged.
F-1	Moderate Tornado 73 - 112 MPH	Roof surfaces peeled off; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
F-2	Significant Tornado 113 - 157 MPH	Roofs torn off frame houses; mobile homes demolished; box cars pushed over; large trees snapped or uprooted; light-object projectiles generated.
F-3	Severe Tornado 158 - 206 MPH	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.

F-4	Devastating Tornado 207 - 260 MPH	Well-constructed houses leveled; structures with weak foundations relocated; cars thrown and large projectiles generated.
F-5	Incredible Tornado 261 - 318 MPH	Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized projectiles hurtle through the air in excess of 100 yards; trees debarked; other incredible phenomena expected.

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Earthquakes - The Modified Mercalli Scale & The Richter Scale

The Modified Mercalli Scale		Level Of Damage	The Richter Scale
1-4	Instrumental to Moderate	No damage.	</= 4.3
5	Rather Strong	Damage negligible. Small, unstable objects displaced or upset; some dishes and glass ware broken.	4.4 - 4.8
6	Strong	Damage slight. Windows, dishes, glassware broken. Furniture moved or overturned. Weak plaster and masonry cracked.	4.9 - 5.4
7	Very Strong	Damage slight-moderate in well-built structures; considerable in poorly-built structures. Furniture and weak chimneys broken. Masonry damaged. Loose bricks, tiles, plaster, and stones will fall.	5.5 - 6.1
8	Destructive	Structure damage considerable, particularly to poorly built structures. Chimneys, monuments, towers, elevated tanks may fail. Frame houses moved. Trees damaged. Cracks in wet ground and steep slopes.	6.2 - 6.5
9	Ruinous	Structural damage severe; some will collapse. General damage to foundations. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground; liquefaction.	6.6 - 6.9
10	Disastrous	Most masonry and frame structures/foundations destroyed. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Sand and mud shifting on beaches and flat land.	7.0 - 7.3
11	Very Disastrous	Few or no masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Rails bent. Widespread earth slumps and landslides.	7.4 - 8.1
12	Catastrophic	Damage nearly total. Large rock masses displaces. Lines of sight and level distorted.	> 8.1

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Volcanic Eruptions - The Volcanic Explosivity Index

Category	Category Description
0	Non-Explosive (Hawaiian) Plume: < 100 m/Volume: > 1000 m3
1	Gentle (Hawaiian - Strombolian) Plume: 100 - 1000 m/Volume: >10,000 m3
2	Explosive (Strombolian - Vulcanian) Plume: 1 - 5 km/Volume: > 1,000,000 m3
3	Severe (Vulcanian) Plume: 3 - 15 km/Volume: > 10,000,000 m3

4	Cataclysmic (Vulcanian - Plinian) Plume: 10 - 25 km/Volume: > 100,000,000 m3
5	Paroxysmal (Plinian) Plume: >25 km/Volume: > 1 km3
6	Colossal (Plinian - Ultraplinian) Plume: > 25 km/Volume: > 10 km3
7	No Adjectival Description Plume: > 25 km/Volume: > 100 km3
8	No Adjectival Description Plume: > 25 km/Volume: > 1,000 km3

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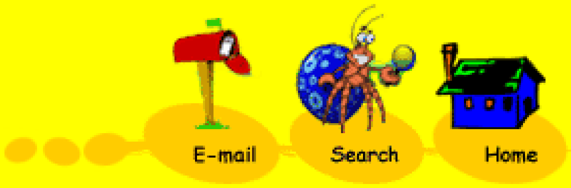

Play "Water, Wind and Earth"!

- Water: Flood and tsunami
- Wind: Hurricane and tornado
- Earth: Earthquake and volcano

Here are the rules:

- Water beats Wind!
- Wind beats Earth!
- Earth beats Water!

Make a choice:

Computer Wins: 0

Reset

Your Wins: 0

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Earthquakes

Earthquake Legends

Different cultures around the world have attempted to explain earthquakes in different ways. Here are some legends about what makes the ground shake!

1. India: The Earth is held up by four elephants that stand on the back of a turtle. The turtle is balanced on top of a cobra. When any of these animals move, the Earth trembles and shakes.

2. Assam (Between Bangladesh and China): There is a race of people living inside the Earth. From time to time, they shake the ground to find out if anyone is still living on the surface. When children feel a quake, they should shout "Alive, Alive!" so the people inside the Earth will know they are there and stop shaking.

3. Mexico: El Diablo, the devil, makes giant rips in the Earth from the inside. He and his devilish friends use the cracks when they want to come and stir up trouble on Earth.

4. Siberia: The Earth rests on a sled driven by a god named Tuli. The dogs who pull the sled have fleas. When they stop to scratch, the Earth shakes.

5. Japan: A great catfish, or namazu, lies curled up under the sea, with the islands of Japan resting on his back. A demigod, or daimyojin, holds a heavy stone over his head to keep him from moving. Once in a while, though, the daimyojin is distracted, the namazu moves, and the Earth trembles.

6. Mozambique: The Earth is a living creature, and it has the same kinds of problems people have. Sometimes, it gets sick with fever and chills and we can feel its shaking.

7. Greece: According to Aristotle, and also to William Shakespeare in a play called Henry IV, strong, wild winds are trapped and held in caverns under the ground. They struggle to escape, and earthquakes are the result of their struggle.

8. Belgium: When people on Earth are very, very sinful, God sends an angry angel to strike the air that surrounds our planet. The blows produce a musical tone that is felt on the Earth as a series of shocks.

9. American Indian: Once a Chickasaw chief was in love with a Choctaw princess. He was young and handsome, but he had a twisted foot, so his people called him Reelfoot. When the princess' father refused to give Reelfoot his daughter's hand, the chief and his friends kidnapped her and began to celebrate their marriage. The Great Spirit was angry and stomped his foot. The shock caused the Mississippi River to overflow its banks and drown the entire wedding party. (Reelfoot Lake, on the Tennessee side of the Mississippi River, was formed as a result of the New Madrid earthquake of 1812.)

10. West Africa: The Earth is a flat disk, held up on one side by an enormous mountain and on the other by a giant. The giant's wife holds up the sky. The Earth trembles when he stops to hug her.

11. India: Seven serpents share the task of guarding the seven sections of the lowest heaven. The seven of them also take turns holding up the Earth. When one finishes its turn and another moves into place, people on the Earth may feel a jolt.

12. Latvia: A god named Drebkuhls carries the Earth in his arms as he walks through the heavens. When he's having a bad day, he might handle his burden a little roughly. Then the Earth will feel the shaking.

13. Colombia: When the Earth was first made, it rested firmly on three large beams of wood. But one day the god Chibchacum decided that it would be fun to see the plain of Bogota underwater. He flooded the land, and for his punishment he is forced to

carry the world on his shoulders. Sometimes he's angry and stomps, shaking the Earth.

14. Scandinavia: The god Loki is being punished for the murder of his brother, Baldur. He is tied to a rock in an underground cave. Above his face is a serpent dripping poison, which Loki's sister catches in a bowl. From time to time, she has to go away to empty the bowl. Then the poison falls on Loki's face. He twists and wiggles to avoid it, and the ground shakes up above him.

15. New Zealand: Mother Earth has a child within her womb, the young god Ru. When he stretches and kicks as babies do, he causes earthquakes.

16. East Africa: A giant fish carries a stone on his back. A cow stands on a stone, balancing the Earth on one of her horns. From time to time, her neck begins to ache, and she tosses the globe from one horn to the other.

17. Central America: The square Earth is held up at its four corners by four gods. When they decide the Earth is becoming overpopulated, they tip it to get rid of surplus people.

18. Romania: The world rests on the divine pillars of faith, hope and charity. When the deeds of human beings make one of the pillars weak, the Earth shakes.

19. West Africa: A giant carries the Earth on his head. All the plants that grow on the Earth are his hair, and people and animals are the insects that crawl through his hair. He usually sits and faces the east, but once in a while he turns to the west and then back to the east, with a jolt that is felt as an earthquake.

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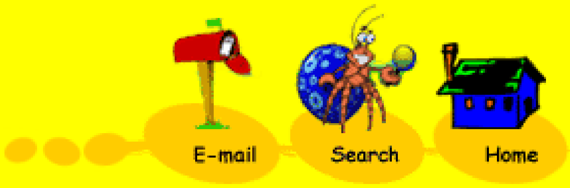
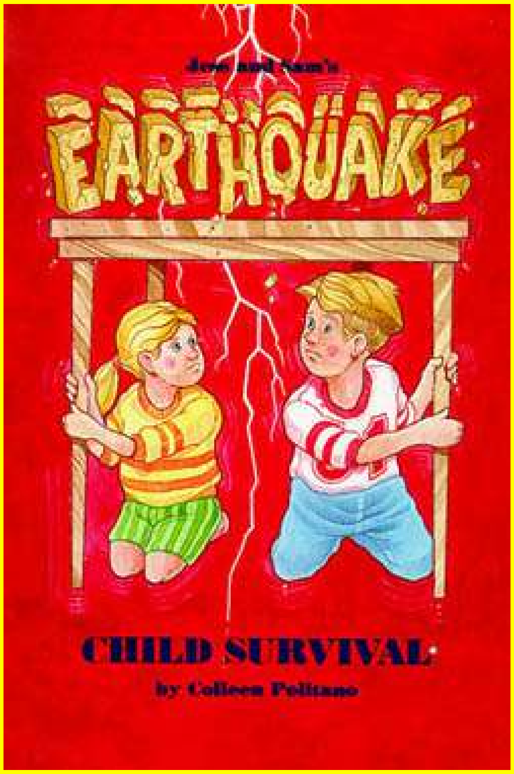


Jess and Sam's Earthquake Activities

An earthquake has shaken their town. Some buildings were damaged, some roads had to be closed, and electricity, water and telephones were disrupted. It was a scary time for Jess and Sam. In the end, they were OK - and they learned a lot about what to do before, during and after an earthquake.



You can learn some of the things Sam and Jess discovered through these experiments. (Reprinted with permission.)

- Experiment #1
- Experiment #2
- Experiment #3

You can read their whole story in Jess and Sam's Earthquake by Colleen Politano, published by Porthole Press Ltd., Canada, and available to buy at Amazon.com.

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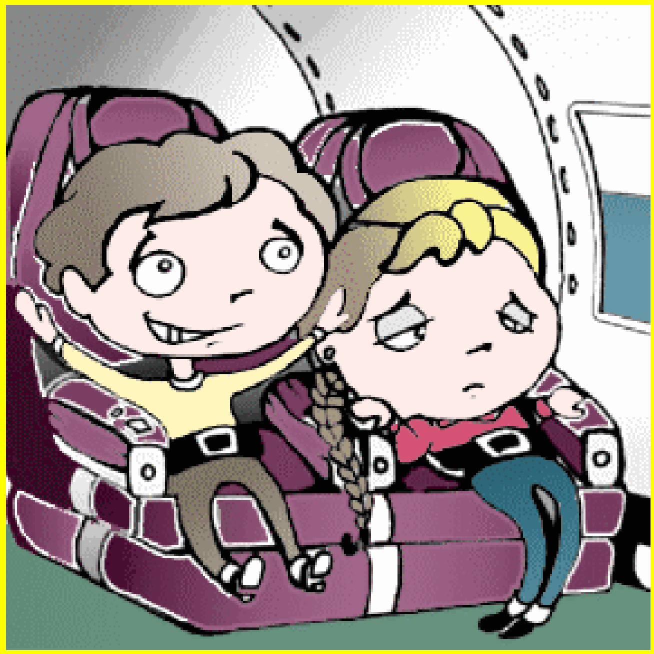
The Shaky Vacation

The twins thought visiting Southern California during their summer vacation was a great idea. Their Uncle James lived there and they could visit the ocean.

Audio

"We can see movie stars in Hollywood and visit amusement parks, too," shouted Julia.

"Let's go!" Robbie jumped up and down with excitement. Their Mom and Dad smiled and said they'd make the plans.



Two weeks later, they were all on a plane to Los Angeles, which Julia didn't like much, but which Robbie thought was "as fun as a rollercoaster."

Their Uncle James picked them up from the airport and took them straight to his house, since they were so tired.

"Take a nap," he said, "Then I'll show you around."

"We don't take naps," said Julia, even as her eyes closed. The twins slept for a few hours and then awoke, ready to explore. Their parents had gone to the ocean and they were glad to be with Uncle James by themselves.

NEXT >>

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Things to Know

Earthquakes

- If you are indoors during an earthquake, keep calm and take cover under a heavy table or desk. Stay away from glass, windows or anything that could fall, like a bookcase.
- If you are outdoors, move away from buildings, street lights and utility wires.
- If you are in a crowded public place, do NOT rush for the doors. Everyone will be doing that. Instead, take cover under something heavy and stay away from things that could fall on you. Stay calm. Do not get in an elevator during an earthquake!
- After an earthquake, be prepared for after shocks. After shocks are follow-up earthquakes that are usually smaller than the first one. They are dangerous because they can cause things that are weakened in the first earthquake to fall down.
- If you are home and you smell gas or hear a hissing or blowing sound, open a window and get out of the building right away. It may mean that a gas line in your house has been broken. Tell your parent or another adult.
- Make sure you are wearing shoes after an earthquake. There may be broken glass on the ground and inside your home.
- If you are scared, share your fears with an adult. Earthquakes can be scary, but remember -- they only last a few seconds.

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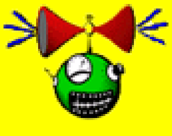
The Turtle Tale

A Native American Legend

In order to listen to the audio file on this page, Real Audio Player is required. Download the free version of Real Player.



Long, long ago, before there were people, there was hardly anything in the world but water. One day, Great Spirit looked down from heaven. He decided to make a beautiful land. But where could he begin? All he saw was water. Then he spotted a giant turtle. Great Spirit decided to make the beautiful land on the turtle's back.

But one turtle was not big enough. The land that the Great Spirit wanted to make was very large. So he called out, "Turtle, hurry and find your six brothers."

Turtle swam away to find them. It took her a whole day to find the first. It took another day to find the next. After six days, Turtle had found her six brothers. "Come," she said. "The Great Spirit wants us."

Great Spirit called down. "Turtles! Form a line, all of you -- head to tail, north to south. Umm -- you have three on the south, please move a little to the east. Hmmm. Yes, that's just right. What a beautiful land you turtles will make! Now listen! It is a great honor to carry this beautiful land on your backs. So you must not move!"

The turtles stayed very still. Great Spirit took some straw from his supply in the sky. He spread it out on the turtle's backs. Then he took some soil and patted it down on top of the straw.

Great Spirit cleaned his hands on a fluffy white cloud. Then he went to work, shaping mountains and valleys and lakes and rivers. When he was finished, he looked at the beautiful land he had made. Great Spirit was very pleased. But soon trouble began. The giant turtles grew restless. They wanted to stretch their legs.

"I want to swim east," said one.

"I want to swim west, with the setting sun," said another.

The turtles began to argue. They could not agree which way to move. One day, four of the turtles began to swim east. The others began to swim west. The Earth shook! It cracked with a loud noise. But after a minute, the shaking stopped. The turtles had to stop moving because the land on their backs was so heavy. They had only been able to swim a little way from each other. When they saw that they could not swim away, they stopped arguing and made up.

Every once in a while, though, the turtles argue again. Each time they do, the Earth shakes!

» Make your own Pop-up Turtle Puppet!

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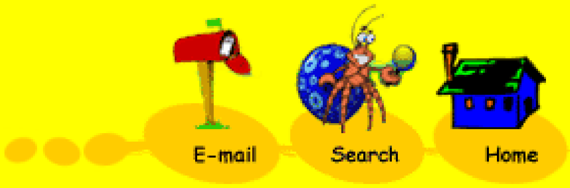
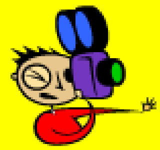
Pets and Disasters



Disasters like hurricanes, tornadoes and floods don't just affect you -- they also affect your pets. And your pets depend on you for their safety. There are many ways to be "Pet Prepared," but you must think ahead and start planning NOW. Your local Humane Society or your veterinarian can help you. During a disaster, if you see an injured or stranded animal that needs help, tell your parent or adult to contact your local animal control officer or animal shelter. Remember, even if you don't have to evacuate, your pet may be stressed or upset and will need extra attention.

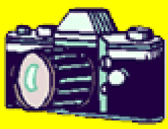

Video Library


If You Need to Evacuate

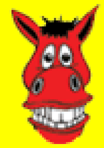

Birds, Reptiles and Other Pets


If you Must Leave Your Pets Behind

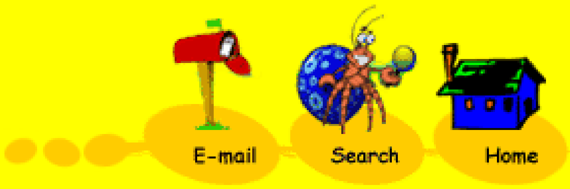

Your Portable Pet Disaster Kit


Photos


Canine Heroes


How Do You Rescue a Horse?

Protect Your Home from Disaster



Disasters happen. There is not much we can do about that. But there are things we can do to protect our homes and reduce the risk that they will be damaged. Reducing the risk is called "mitigation." Although some mitigation is very expensive and complicated -- like moving your home to a different piece of land that is higher or away from a river -- some things are easy. Here are some things you and your family can do to mitigate:

» Click Here For Mitigation Photos


Floods

- Don’t put valuable items and appliances in the basement where they are more likely to be flooded.
- Power and water don’t mix! Have the main breaker or fuse box and the utility meters raised above the flood level for your area. That way, if your home floods, water won’t damage your utilities.
- Buy flood insurance. To learn more about flood insurance, have your parent call 1-800-427-4661.


Hurricanes and Tornadoes

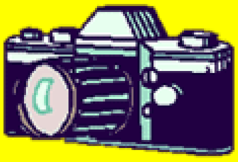
- Don’t lose your roof to high winds! Have hurricane straps installed to keep the roof attached to the walls.
- Use storm shutters to protect windows and glass. Use them when severe weather is coming. The storm shutters protect against flying debris like tree trunks or other things carried by strong winds.


Earthquakes

- Bolt or strap cupboards and bookcases to the walls and keep heavy objects on the lower shelves so they don’t fall on people.
- Strap your water heater to a nearby wall. This will keep your gas water heater from falling on someone or starting a fire from a broken gas main.
- Have your home bolted to the foundation. Anchor bolts cost as little as $2 each. They should be installed every six feet on the outer edges of your house.


Wild Fires

- Create a safety zone around the house that separates your home from plants and bushes that can burn easily. Clear dead brush and grass from your property. It will act as fuel for a fire.
- Keep branches around your home free of dead or dying wood or moss.
- Put tile or flame-retardant shingles on your roof instead of wood shakes or standard shingles. This will cut the chance that burning debris in the air will catch your roof on fire.



Photos

Earthquake Photos

Please click on image for a larger view and caption.











Canine Heroes

Since 1989, FEMA has coordinated an Urban Search and Rescue system. This system has 27 teams, funded by FEMA, which are located in many different states. These teams are specially trained and equipped to find people who are trapped by a structural collapse. The collapse might be caused by a hurricane, earthquake or explosion.

Each task force can be activated in an emergency and can arrive at the disaster within hours. Each team has 62 specialists, including medical personnel, structural engineers - and search specialists. The search specialists include canine specialists - highly trained and certified dogs that know how to safely go into collapsed structures and how to systematically search an area. They know how to locate trapped people and then how to let their trainer know what they have found. These very special dogs work hard and save lives. They are constantly training to keep up their skills. They usually live with their trainers and ride in helicopters, boats and airplanes in order to get to their job fast. They are real Canine Heroes!

Click here for thumbnails of the Canine Heroes trading cards. New cards will be posted periodically. Visit back often and collect the whole set!

New York Urban Search & Rescue Canine Photos

FEMA for Kids

Federal Emergency Management Agency

Volcano Watch: Mapping New Lava

Geologists everywhere like to study rocks in the field, but few of them get to map rocks that are still molten and on the move. In Hawaii, scientists with the U.S. Geological Survey map the new lava flows erupted from Kilauea Volcano to determine their extent and volume.

Mapping also helps to keep track of how fast flows are advancing toward areas where people live. In the past three years, the way scientists map lava has undergone a revolution. Instead of trying to figure out a flow's location and then mark it on paper maps or aerial photographs, scientists now map with portable GPS (Global Positioning System) receivers.

These devices receive the radio waves from global positioning system satellites to determine the position of the receiver on the Earth's surface. Portable receivers record positions to within 15 feet, which is well suited for lava-flow maps.

To map flows, scientists walk around them as near their edges as possible, noting their characteristics and position. With GPS receivers, the position is recorded by pushing a button, and the data are recorded in the computerized memory of the device. Back in the office, scientists download the coordinates and connect the dots, so to speak. The result is an outline of the lava flow.

It's easy to distinguish the margin of a new flow where it laps against substantially older flows. New flow is a shiny, silvery gray color, because none of its glass, which forms most of the rock, has altered chemically or physically. If the flow is less than a week old, scientists may feel substantial heat as we approach it or step onto it. Shimmering heat waves in the air above a recent lava flow may give it away, too.

If the mapping doesn't begin until the flow is cool, it can be more difficult to recognize new flow from old flows. Scientists will look for other clues, including burned trees or brush, ash from the burned vegetation and subtle differences in color. Scientists say that the law flows begin to revegetate quickly - meaning plants return to the area. Even near flows only a few months old, tiny ferns can be seen sprouting where moisture collects.

Volcanoes

E-mail Search Home

Volcano Facts

More than 80 percent of the earth's surface is volcanic in origin. The sea floor and some mountains were formed by countless volcanic eruptions. Gaseous emissions from volcano formed the earth's atmosphere.

The May 18, 1980 eruption of Mount St. Helens in the Cascade Range of Washington State happened after more than 100 years of dormancy (a time when the volcano was "asleep.") When the volcano erupted, it took the lives of 58 people and caused $1.2 billion in damage.

The 1992 eruption of Mount Pinatubo in the Philippines Islands caused 342 deaths and more than 250,000 people had to be evacuated.

There are more than 500 active volcanoes in the world. More than half of these volcanoes are part of the "Ring of Fire," a region that encircles the Pacific Ocean.

The rock debris carried by a lateral blast of Mount St. Helens traveled as fast as 250 miles per hour.

Crater Lake in Oregon formed from a high volcano that lost its top after a series of tremendous explosions about 6,600 years ago.

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Volcanoes

Mount St. Helens

Mount St. Helens is located in southwestern Washington State, about 50 miles northeast of Portland, Oregon. It is in the Cascade Range of mountain. It was named in 1792 in honor of the Baron St. Helens. American Indians of the Pacific Northwest called it "Louwala-Clough" or "smoking mountain." The volcano was active in the mid-1800s, but most people in this century did not see it as a menace. In fact, the mountain was snow-covered and very beautiful. The forest on it and around the base was filled with wildlife. At the base of the volcano was Spirit Lake, a clear mountain lake that was very good for fishing and boating.

In the spring of 1980, everything changed. First, there was a series of earthquakes and then came one or maybe two thunderous explosions. Mount St. Helens began to spew forth ash and steam. Two craters formed on the volcano and there were avalanches of snow and ice, darkened by ash. Over the next two months, the volcano continued to be active, simmering almost like a pot boiling on a stove. Then on May 18, 1980, the volcano suddenly erupted. Part of the volcano collapsed and became a huge landslide that eventually covered an area of about 24 square miles. There was also a release of pent-up pressure form within the volcano. There was a huge blast of rock, ash and hot gases that devastated an area of about 230 square miles north of the volcano. To the south, the devastated area was much less. Scientists have calculated the blast started at about 220 miles per hour but increased to about 670 miles per hour. The blast was heard as far away as Montana, Idaho, Canada and California.

The eruption cost 57 lives and many injuries. Many buildings were buried and more than 200 houses and cabins were destroyed. Many tens of thousands of acres of prime forest, as well as recreational sites, roads and trails were destroyed or heavily damaged. More than 185 miles of highway and roads were destroyed or extensively damaged. Four billion board feet of timber was damaged or destroyed and many animals, including dear, elk and bear were killed. Many small animals, such as rodents, frogs and crawfish managed to survive because they were below ground level or water surface. While the ash destroyed many crops in the area, the ash may provide beneficial chemical nutrients to the soil in the future.

Mount St. Helens information courtesy of U.S. Geological Survey/Department of the Interior.

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Volcanoes

Pele - Tale Of The Volcano Goddess

The Native Hawaiians knew all about volcanoes. According to them, volcanic eruptions were caused by Pele, the beautiful but tempestuous Goddess of Volcanoes. Pele had frequent moments of anger, which brought about eruptions. She was both honored and feared. She could cause earthquakes by stamping her feet or volcanic eruptions and fiery lava by digging with her Pa'oa, her magic stick.

Pele had a long and bitter argument with her older sister, Namakaokahai. The fight ended up forming the Hawaiian Islands.

First, Pele used her magic stick on Kauai, but she was attacked by her older sister and left for dead. Pele recovered and fled to Oahu, where she dug several "fire pits," including the crater we now called Diamond Head, in Honolulu. After that, Pele left her mark on the island of Molokai before traveling further southeast to Maui and creating the Haleakala Volcano. By then, Namakaokahai, Pele's older sister, realized she was still alive and she went to Maui to do battle. After a terrific fight, Namakaokahai again believed that she had killed her younger sister. But Pele was still alive and she was busy working at the Mauna Loa Volcano, on the big island of Hawaii. Finally, Namakaokahai realized that she could never crush her sister's indomitable spirit and she gave up the struggle. Pele dug her final and eternal fire pit, Halemaumau Crater, at the summit of Kilauea Volcano. She is said to live there to this day.

Information courtesy of the U.S. Geological Survey/Department of the Interior.

Things to Know

Volcanoes

Do not visit the volcano site. You could be killed by a sudden explosion. Public officials may tell you where it is safe to view.

If there is ash in the air, avoid being downwind from the volcano. A building offers good shelter from volcanic ash, but not from lava flows or rocks. If ash is falling, stay indoors unless there is a danger of the roof collapsing. Close doors, windows and all ventilation in the house. Cover your nose and mouth to avoid breathing ash.

Be aware of flying rocks and mudflows. Mudflows can move faster than you can walk or run.

If you live near a volcano, you should have an evacuation plan. Know what route you will take if you must evacuate and have a back-up route, too. Also, if you live near a volcano it is good to have a pair of goggles and a throw-away breathing mask for each member of your household.

After an eruption, if you have ash on your roof, clear it away as soon as you can. The ash is heavy and could cause the roof to collapse.

Volcano Photos

Click on image for a larger view and caption.







Get Ready, Get Set...

E-mail Search Home

Every family should have a Disaster Supply Kit in their home. The kit will help you and your family during a disaster. In a hurricane or earthquake, for example, you might be without electricity and the water supply may be polluted. In a heavy winter storm or flood, you may not be able to leave your house for a few days. In times like this, you will need to rely on yourself. Your disaster supply kit will make it easier. Remember, your family will probably never need to use your disaster supply kit, but it's always better to be prepared.

Above is a picture of a Disaster Supply Kit. It is best if these items are kept in a plastic tub or kept together in a cabinet so they will be easy to find. Click on the items in the box to learn more about the supplies you'll need and why they are important!

Family Disaster Plan

[Kids Activity Survival Kit]

FEMA for Kids

Federal Emergency Management Agency

National Oceanic and Atmospheric Administration

National Weather Service

WORKING TOGETHER TO SAVE LIVES

West Coast & Alaska Tsunami Warning Center

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- Other Center's
- Get It By Email

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- Earthquake FELT?
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- Messages Defined

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- TsunamiReady
- Links & References

Contact Us
- WCATWC

Click HERE for the Current Tsunami Information!

Click name for link to local Emergency Service Office:
Alaska, British Columbia, Washington, Oregon, California, or Hawaii

Virtual Earthquake Simulation.

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Palmer, AK 99645 USA
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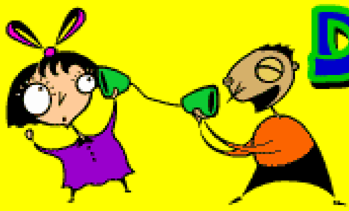
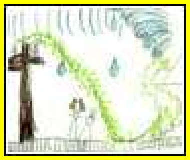
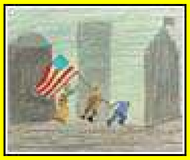


Disaster Connection Kids to Kids



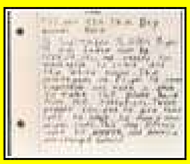
A View Of Hurricane Isabel By students of Texie Camp Marks Children's Center
[Artwork & Letters]

A View of Tornadoes By students of Alabama Christian Academy
[Artwork & Letters]



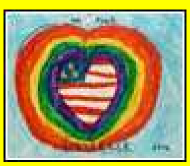
In Remembrance of 9/11: Chagrin Falls Intermediate School
[Artwork & Letters]

In Remembrance of 9/11: Gleason Lake Elementary School
[Artwork & Letters]

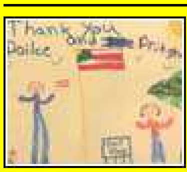


In Remembrance of 9/11: Franklin Elementary School
[Letters]

In Remembrance of 9/11: 1st Kids Preschool/Daycare
[Artwork & Letters]



In Remembrance of 9/11: Elizabeth Blackwell Elementary
[Artwork & Letters]

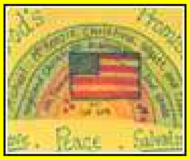


Celebrating Sept. 11, 2002 -- Patriot's Day
[Artwork]

Let Freedom Ring, From Sutton Public School
[Artwork]


Alabama Christian Academy Illustrates Tornadoes
[Artwork]

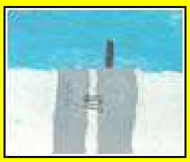

Boyce, Virginia, Students Thank FEMA
[Artwork]


Highland Christian Academy Express their Unity
[Artwork]


Students Say Thank You to Washington DC Firefighters
[Artwork]


Students From South Knox Elementary School, Vincennes, Indiana, Thank The Rescue Workers In New York And The Pentagon
[Artwork | Poems]


Sammamish, Washington, Students Thank Rescue Workers
[Artwork]


The World Trade Center Attacks: A Child's Point of View
[Artwork]


Georgia Children Make Cards for Children in New York, Virginia
[Artwork]


Hurricane Drawings from Tampa Downtown Preschool and Kindergarten
[Artwork]


Students' tornado drawings
[Artwork]


Disaster from a Kid's Point of View
[Story]

Thomas' Tornado Story
[Story]

» Archives

FEMA for Kids
Federal Emergency Management Agency

Help

Resources For FEMA Web Site Users

Viewer Privacy and Security Notice

Introduction

1. This World Wide Web (WWW) site is provided as a public service by the Federal Emergency Management Agency, FEMA.

2. Information presented on this FEMA WWW site is considered public information and may be distributed or copied. Use of appropriate byline/photo/image credits is requested.

Information collected and stored automatically

1. The information we learn about you from your visit to our website depends upon what functions you perform when visiting our site.

2. For site management, information is collected for statistical purposes. This government computer system uses software programs to create summary statistics, which are used for such purposes as assessing what information is of most and least interest, determining technical design specifications, and identifying system performance or problem areas.

3. If you do nothing during your visit but browse through the website, read pages, or download information, we will gather and store certain information about your visit automatically. This information does not identify you personally. We automatically collect and store the following information about your visit:

- The Internet domain (for example, "xcompany.com" if you use a private Internet access account, or "yourschool.edu" if you connect from a university's domain) and IP address (an IP address is a number that is automatically assigned to your computer whenever you are surfing the Web) from which you access our website;
- The type of browser and operating system used to access our site;
- The date and time you access our site;
- The pages you visit; and
- If you linked to the FEMA website from another website, the address of that website.

  We use this information to help us make our site more useful to visitors -- to learn about the number of visitors to our site and the types of technology our visitors use. We do not track or record information about individuals and their visits.

Cookies:

1. The only cookies FEMA uses on its web are those that allow several complex software

user-driven applications to work correctly. For instance, our online ordering services (for publications of the U.S. Fire Administration and for the FEMA Flood Map Store) allow users to "shop" through the catalog. As a user goes through and checks off a series of publications, each transaction is a separate "signal" sent between their computer and ours. In order to maintain a complete record of the total order, the FEMA server sends a cookie to identify that user's order. The only information collected is related to that particular publication order and this information is NOT retained once the order is sent.

- This is the state of technology on the Web. There currently exist no non-cookie applications for this multi-order function.

Please be assured that FEMA's use of cookie technology is NOT a covert attempt to either collect or analyze information on Internet users.

Information Collected from E-mails and Web Forms

If you identify yourself by sending an E-mail or using Web Forms:

- You also may decide to send us personally-identifying information, for example, in an electronic mail message containing a complaint or compliment. We use personally-identifying information from viewers in various ways to further the usefulness and accuracy of the information contained on our Web site or to add new sections and services. Visit Feedback, http://www.fema.gov/feedback/, to learn what can happen to the information you provide us when you send us e-mail.
- ***We want to be very clear: We will not obtain personally-identifying information about you when you visit our site, unless you choose to provide such information to us.***

Security and Intrusion Detection

1. For site security purposes and to ensure that this service remains available to all users, this government computer system employs software programs to monitor host and network traffic to identify unauthorized attempts to upload or change information, or otherwise cause damage.

2. Except for authorized law enforcement investigations, no other attempts are made to identify individual users or their usage habits. Raw data logs are used for no other purposes and are scheduled for regular destruction in accordance with National Archives and Records Administration guidelines.

3. Unauthorized attempts to upload information or change information on this service are strictly prohibited and may be punishable under the Computer Fraud and Abuse Act of 1986 and the National Information Infrastructure Protection Act."

Privacy Statement Relating to System Of Records

The FEMA Flood Map Store provides dissemination of FEMA's flood map and insurance products for an associated fee. The following relate to the purchase of FEMA flood related products.

E-Commerce Privacy Statement

1. Personal information submitted by a user in a comment or question via phone, fax, or e-mail is not distributed to parties outside of the FEMA Flood Map Store.

2. Only information submitted through the FEMA Flood Map Store ordering process is protected. Please do NOT include credit card information in E-mail. The open nature of Internet E-mail prevents FEMA from protecting information provided in E-mail.

3. Using commercially available services for security and credit card transactions, the FEMA Flood Map Store ensures that only authorized personnel view credit card numbers that are submitted through the FEMA Flood Map Store.

4. Personal information that is supplied by a user when submitting an order via the FEMA Flood Map Store, phone, fax, or e-mail is used for fulfilling that order. This information may be used to notify customers of new products that may be of interest to them.

5. Where identifying information is asked, it is used only for responding to users' comments or questions and is not made available for other purposes.

6. To assist users in finding official Government information, we provide links to other Web

sites. Once users have left *the FEMA Flood Map Store* and entered another site, they are subject to the privacy policy of that site.

7. As noted above, session (temporary) cookies, not permanent cookies, are used to facilitate the on line ordering process.

Map Service Center Encryption Statement

The FEMA Flood Map Store utilizes industry standard Secure Socket Layer, SSL, encryption in conjunction with freely available web browsers. The SSL technology ensures private, secure transactions for customers who submit electronic orders by credit card through the FEMA Flood Map Store.

Last Updated: Tuesday, 11-Feb-2003 08:54:28 EST

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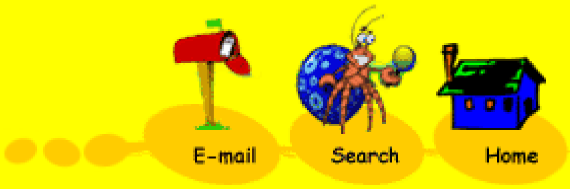

Awards We've Received

FEMA for Kids was included in Eisenhower National Clearinghouse's (ENC) Publication "ENC Focus" for the week of March 8, 2004.

FEMA for Kids was accepted as a Wiredkids Safe Site on August 14, 2003.

FEMA for Kids received the Stepduck Seal of Approval on February 24, 2003.

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animated graphic of man with telescope

FEMA for Kids was selected as one of the best child safety education websites on the Internet by Kidz Printz on January 27, 2003.

FEMA for Kids was selected as one of "Mac's Picks of the Week" on November 26, 2002.

FEMA for Kids is a homework spotlight site at HomeworkSpot.com

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FEMA for Kids is featured in an article at GovSpot.com

FEMA for Kids selected as one of the "Seven Super Sites of the Month" for April 1999 by Kids' Space.

FEMA for Kids selected as a showcase site on the 911 Fire Police Medical Web site.

FEMA for Kids selected by the editors of Bonus.com, the SuperSite for Kids

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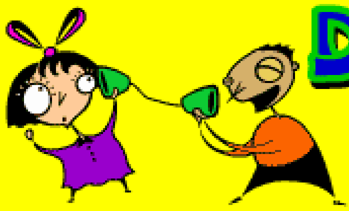
» Good Things Being Said By Our Visitors



Disaster Connection Kids to Kids

Disaster From A Kid's Point Of View

By Maggie, age 13

I live in Arkansas, as you know we had a terrible ice storm, and my family lost a lot of things. We had no power for two weeks and my family had no house! We are very thankful for the Red Cross, they brought food to everyone (my mom and I helped deliver every day). Since we had no house and no insurance on our "broken" home, we called FEMA. My mom was the fist to call, from our area, and we received money for our house and a place to stay until we got a new house. I would like to thank you and the entire FEMA team because if it wasn't for you I could not be sitting here in my own room typing you this letter of thanks!

FEMA for Kids

Federal Emergency Management Agency

Fill in the blanks, using the words from the drop down boxes below. There are rhyming words below each blank to help you. Good luck.

1. If you are indoors, stay inside until the storm ______ .

(glasses)

2. Don't use the ______ . Telephone lines conduct electricity.

(loan)

3. Don't take a ______ . Water can also carry an electric charge if lightning strikes near your home.

(power)

4. If you are outdoors, try to get to a safe shelter quickly. Move away from ______ things like trees, towers, fences, and telephone/power lines. They can attract lightning.

(ball)

5. If you are stuck outside and surrounded by trees, take shelter under the ______ trees.

(porter)

6. If you are outside in an open area go to a ______ lying place like a ditch or a valley.

(snow)

7. Stay away from ______ objects! They can attract lightning.

(petal)

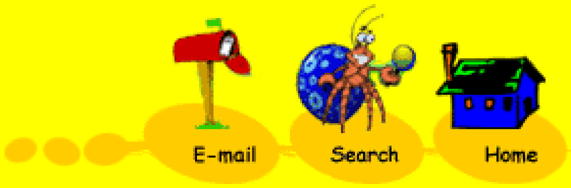
8. Make yourself ______ by crouching down and putting your hands on your knees.

(fall)

Submit your answers

Important Terms | What is Lightning? | If Someone is Hit by Lightning | Lightning Fact and Fiction

Thunderstorms



Important Terms

A severe thunderstorm watch is issued by the National Weather Service when the weather conditions are such that a severe thunderstorm is likely to develop. (A severe thunderstorm has winds at least 58 miles per hour or hail at least three-fourths of an inch in diameter.) When you hear a thunderstorm watch, go to a safe place right away and listen to the radio or television for more information.

A severe thunderstorm warning is issued when a severe thunderstorm has been sighted or indicated by weather radar. A warning is more severe than a watch. If you are not already in a safe place, get there at once! Listen to a battery-operated radio or television and wait for the "all clear."

[Important Terms | What is Lightning? | If Someone is Hit by Lightning | Lightning Fact and Fiction]

FEMA for Kids

Federal Emergency Management Agency

Lightning Safety By Sabrina

Hello, my name is Sabrina. I was hit by lightning, while taking a hike in the Grand Canyon. Believe me being hit by lightning is not fun! I want you to know how to protect yourself from lightning, so here are some basic lightning safety tips that can help you to be safer.

Outdoor Lightning Safety Tips

1. The very first thing to do is to make a lightning safety plan with your parents or your group and follow it.

2. Before going on a long hike be sure to check the weather forecast for the day.

3. When hiking: assign one person to look for big puffy clouds, that might be coming your way or growing. Have another person be in charge of spotting possible shelters all along the way in case you need them on the way back. A third person should watch and listen for lightning and thunder. (See "Flash to Bang" below) another person should be in charge of deciding when it is time to go back.

4. If you are caught in a thunderstorm, try to find a low place to stay in until the storm is over.

5. If you cannot find a shelter, get in to the "lightning safety position," squat down near the ground with your heels touching and put your hands over your ears. See Position Drawing.

6. Do not go under a tree for shelter because if you do the lightning could hit the tree and travel under the ground or "splash" from the tree and hit you.

7. If you are playing out side and get caught in a thunderstorm go into a nearby building or enclosed car (with the windows rolled up).

Indoor Lightning Safety Tips

1. During a thunderstorm, stay away from anything that is metal (yes, even the refrigerator) because lightning can come into the house through wires and pipes.

2. When there is a thunderstorm outside do not stand near the windows.

3. Don't take a shower or bath when there is a thunderstorm.

4. Never use the phone during a thunderstorm and if the phone rings don't answer it. Because lightning could hit the phone line and travel though the line and zap you though the phone. Some people have died that way.
   Portable phones aren't connected to wires, but lightning could still cause a loud "pop" that could hurt your ear.

5. A metal Franklin stove/fireplace with a metal chimney could also provide a path for lightning to enter your house.

Things To Watch Out For

1. If you are outside and you can hear thunder, then the storm is close enough to be dangerous.

2. If you and a friend are outside someplace, and you see your friend's hair start to stand up, you are in danger! You could also feel prickles on your skin. The reason that you are in danger is that a lightning charge is building up somewhere very close by. Lightning may strike any second and you could be hit by lightning and be badly injured or killed.

What To Do If Someone Is Hit By Lightning

1. It is not dangerous to touch someone who has just been hit by lightning.

2. If someone is hit by lightning and there is still thunder take the person to a near by shelter (a building or car).

3. Once the person is in a safe place, send for help.

4. If the person is not breathing, CPR must be done immediately.

What Are Safe Shelters, And What Are Not Safe Shelters?

1. Buildings or cars (not convertibles and be sure that windows are closed) are the safest place to be during a thunderstorm. If there is not a building or car near you, a ditch, ravine or a deep cavern might be safer than being out in the open.

2. Standing under a tree is not a safe place to be in a thunderstorm. It may keep the rain off you but if lightning hits the tree, it might kill you.

3. You may have heard that if you can't find a shelter, you should lie down flat on your stomach. Well, doing that is not safe at all! If lightning hits someplace near you and travels through the ground, it could enter your whole body and electrocute you. Instead get into the lightning safety position.

What To Do If You Are On A Sport Team?

If you are on a sport team and there is a thunderstorm during a game, what should you do? Should you tell your coach or the person in charge, that the team should get off the field? If the coach says it is just a little rain and not to worry about it, should you leave anyway and take shelter? This is a serious question. You could get kicked off the team if you leave, but your life is more important than the game. In 1999, a whole soccer team was killed by lightning in Africa and a whole football team was injured by lightning in Colorado. My advice is to discuss this question with your parents and with your coach and team before the season begins. On my website you can find links to lightning scientists and find professional advice.

"Flash To Bang"

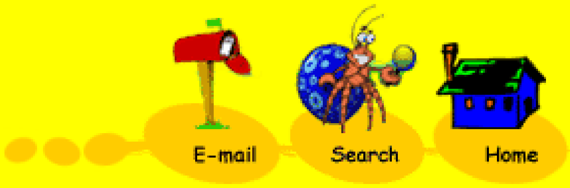
"Flash to bang" is a way to measure how far away the lightning strike was. The sound of thunder can go one mile in five seconds. So if you see the lightning strike and hear the thunder ten seconds ten seconds later, you know the lightning was two miles away. Scientists say that if you are less than six miles away, you are in the high danger zone. Scientists know that lightning can strike several miles away from a storm cloud.

See my website for more information.

FEMA for Kids

Federal Emergency Management Agency

Thunderstorms

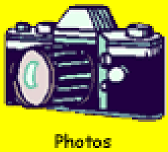


What Is Lightning?

The action of rising and descending air within a thunderstorm separates positive and negative charges. Water and ice particles also affect the distribution of electrical charge. Lightning results from the buildup and discharge of electrical energy between positively and negatively charged areas. Most lightning occurs within the cloud or between the cloud and ground.

The average flash of lightning could turn on a 100-watt light bulb for more than 3 months. The air near a lightning strike is hotter than the surface of the sun! The rapid heating and cooling of air near the lightning channel causes a shock wave that results in thunder.

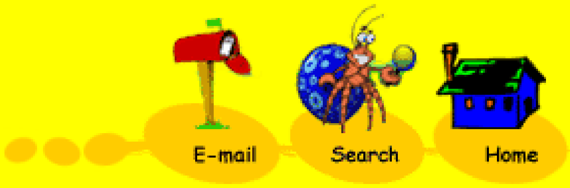
Your chances of being struck by lightning are estimated to be 1 in 600,000 but those chances can be reduced by following safety rules. Most lightning deaths and injuries occur when people are caught outdoors, and most happen in the summer. Many fires in the western United States and Alaska are started by lightning. In the past 10 years, more than 15,000 fires have been started by lightning.



[Important Terms | What is Lightning? | If Someone is Hit by Lightning | Lightning Fact and Fiction]

FEMA for Kids
Federal Emergency Management Agency

Thunderstorms



If Someone Is Hit By Lightning

People who have been struck by lightning are safe to handle - they don't carry an electrical charge.

Call for help. Get someone to dial 9-1-1.

Being struck by lightning can cause burns or nervous system damage, broken bones and loss of hearing and eyesight. It is a very serious emergency.

If you know how, give first aid. If you know how and the person has stopped breathing, begin rescue breathing. If their heart has stopped beating, and you know how, give CPR.

[Important Terms | What is Lightning? | If Someone is Hit by Lightning | Lightning Fact and Fiction]

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Federal Emergency Management Agency

Thunderstorms

Lightning Fact And Fiction

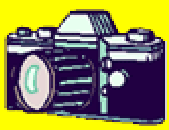
Fiction: Lightning never strikes the same place twice.
Fact: Lightning has "favorite" sites that it may hit many times during one storm.

Fiction: If it is not raining, then there is no danger from lightning.
Fact: Lightning often strikes outside of heavy rain and may occur as far as 10 miles away from any rainfall.

Fiction: The rubber soles of shoes or rubber tires on a car will protect you from being struck by lightning.
Fact: Rubber-soled shoes and rubber tires provide NO protection from lightning. However, the steel frame of a hard-topped vehicle provides increased protection if you are not touching metal. Although you may be injured if lightning strikes your car, you are much safer inside a vehicle than outside.

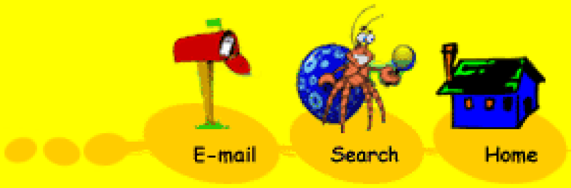
Fiction: People struck by lightning carry an electrical charge and should not be touched.
Fact: Lightning-strike victims carry no electrical charge and should be attended to immediately.

Fiction: "Heat lightning" occurs after very hot summer days and poses no threat.
Fact: What is referred to as "heat lightning" is actually lightning from a thunderstorm too far away for thunder to be heard. However, the storm may be moving in your direction!



[Important Terms | What is Lightning? | If Someone is Hit by Lightning | Lightning Fact and Fiction]

Thunderstorms



Things To Know

When a storm is coming, look for darkening skies, flashes of light or increasing wind. Listen for the sound of thunder. If you can hear thunder, you are close enough to the storm to be struck by lightning. Go to safe shelter immediately. Find shelter in a building or car. Keep car windows closed and avoid convertibles.

Telephone lines and metal pipes can conduct electricity. Unplug appliances, avoid using the telephone or any electrical appliances. (Leaving electrical lights on, however, does not increase the chances of your home being struck by lightning.)

Don't take a bath or shower.

Turn off the air conditioner. Power surges from lightning can overload the compressor and damage the air conditioner!

Draw blinds and shades over windows. If windows break due to objects being blown by the wind of a storm, then the shades will prevent glass from shattering into your home.

If you are caught outside during a thunderstorm, you must act immediately:

If you are in the woods, take shelter under the shorter trees.

If you are boating or swimming, get to land and find shelter right away!

If you can go to a low-lying, open place away from trees, poles or metal objects. Make sure the place you pick is not subject to flooding.

Become a very small target! Squat low to the ground. Place your hands on your knees with your head between them. Make yourself the smallest target possible.

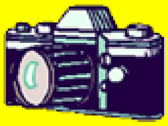
Do not lie flat on the ground - this will make you a larger target!

[Important Terms | What is Lightning? | If Someone is Hit by Lightning | Lightning Fact and Fiction]

FEMA for Kids

Federal Emergency Management Agency

What You Might Feel in a Disaster



Photos

Disasters can happen. They often happen quickly and without warning, and they can be scary for you and your parents. For example, you may have to leave your home and you may not be able to go to school. You may not be able to sleep in your own bed and things may be confusing for awhile. There are **SIX** important things to remember:

1 2 3 4 5 6

Thunderstorms

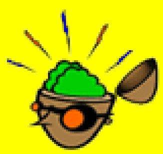
E-mail | Search | Home

Lightning Photos

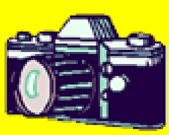
Click on the image for a larger version and photo credit.







Things to Know


What You Might Feel in a Disaster


Photos


NOAA Radio


What Did You Learn?

[Important Terms | What is Lightning? | If Someone is Hit by Lightning | Lightning Fact and Fiction]

FEMA for Kids

Federal Emergency Management Agency

NOAA Weather Radio

Get The News About Your Weather - With A NOAA Weather Radio

Did you know there is a radio that broadcasts National Weather Service warnings and watches 24 hours a day - and warns you with an alarm of dangerous weather? It's true. It's called the NOAA Weather Radio network, and it's provided as a public service by the Department of Commerce's National Oceanic and Atmospheric Administration.

The NOAA Weather Radio network has more than 480 stations in the 50 states and in Puerto Rico, the U.S. Virgin Islands and U.S. Pacific Territories.

How does the radio work? National Weather Service forecasters provide routine weather programming all the time to help you plan. The radios also send out a special alarm tone to alert you to a life-threatening situation. Why is that important? Sometimes, weather can turn deadly very fast. Tornadoes are the best example. Tornadoes may strike when people are sleeping or unaware of the forecast. Tornadoes can be deadly if people cannot seek an appropriate shelter - like a basement or a in-house safe room. With the NOAA Weather Radio, you will be alerted to dangerous weather with time to take shelter.

NOAA Weather Radios broadcast more than just warning about natural hazards. They also broadcast warnings and information and technological disasters, such as chemical releases or oil spills.

Every house should have a NOAA Weather Radio - just the way all houses should have a smoke detector. They can be purchased at stores that sell electronics. Most run on batteries or have battery back-up. Be sure to take it with you when you travel or are out boating or camping.

Be weather-safe. Have a NOAA Weather Radio!

What is the abbreviation for the Federal Emergency Management Agency?

- ○ FEA
- ○ FEMA
- ○ FMEA
- ○ USA.GOV

What is an Executive Branch agency?

- ○ A federal government agency that reports to the President
- ○ A federal government agency that reports to an executive
- ○ A federal government agency that works with trees

The Federal Emergency Management Agency helps people BEFORE, DURING, and AFTER a disaster.

- ○ True
- ○ False

Choose one thing that the Federal Emergency Management Agency DOES NOT do to help people.

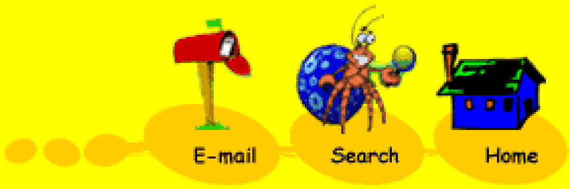
- ○ Helps people find a place to stay after a disaster
- ○ Helps people repair their homes
- ○ Works with city officials to fix public buildings that are damaged
- ○ Teaches kids how to swim
- ○ Teaches people how to prepare and make their homes safer
- ○ Trains firefighters and emergency workers
- ○ Runs a flood insurance program

Get My Score

FEMA for Kids

Federal Emergency Management Agency

Hurricanes



The 15 Biggest Hurricanes From 1900-2000

1. Unnamed storm, which hit the Florida Keys in 1935. Category 5
2. Camille, which hit Mississippi, Louisiana and Virginia in 1969. Category 5
3. Andrew, which hit Florida and Louisiana in 1992. Category 5
4. Unnamed storm, which hit the Florida Keys and Texas in 1919. Category 4
5. Unnamed storm that hit Lake Okeechobee, Florida, in 1928. Category 4
6. Donna, which hit Florida and the Eastern U.S. in 1960. Category 4
7. Unnamed storm, which hit Galveston, Texas, in 1900. Category 4
8. Unnamed storm, which hit Grand Isle, Louisiana, in 1909. Category 4
9. Unnamed storm, which hit New Orleans, Louisiana, in 1915. Category 4
10. Carla, which hit Texas in 1961. Category 4

According to the National Weather Service Tropical Prediction Center

FEMA for Kids — Federal Emergency Management Agency

Hurricanes

The History Of Hurricanes

Scientists have only been studying hurricanes only for about 100 years. But there is evidence of hurricanes occurring long in the past. For example, geologists (scientists who study the earth) believe that layers of sediment in a lake in Alabama was brought there by a hurricane in the Gulf of Mexico as long as 3,000 years ago! There is also evidence in Florida of hurricanes more than 1,000 years ago.

One of the first human records of hurricanes appears in Mayan hieroglyphics. The Mayans also practiced a kind of mitigation and risk reduction by building their major settlements away from the hurricane-prone coastline. In fact, it is the Mayan word "Hurakan" that became our word "hurricane." Hurakan was the name of one of their gods, who, they believed, blew his breath across the water and brought forth dry land. Later, Carib Indians gave the name "Hurican" to one of their gods of evil.

Many storms left important marks on history. In 1565, a hurricane scattered a French fleet of war ships and allowed the Spanish to capture a French fort in what is now Florida. In 1609, a fleet of ships carrying settlers from England to Virginia was struck by a hurricane. Some of the ships were damaged and part of the fleet grounded on Bermuda, an island nation in the Atlantic. These passengers became the first people to live on Bermuda. In 1640, a hurricane partially destroyed a large Dutch fleet that was poised to attack Cuba.

There were a number of particularly severe hurricanes as the U.S. went from the 1800s to the 1900s. Hurricanes hit Louisiana, South Carolina and Georgia in 1893 and killed as many as 4,000 people. In 1900, a famous Texas hurricane killed more than 8,000 people and was a Category 4 storm.

As forecasting improved communities were no longer surprised by hurricanes and could take measures to evacuate ahead of the storm. While destruction still continues, the number of deaths in hurricanes had dropped significantly.

Information courtesy of the Hurricane Research Division of the Atlantic Oceanographic and Meteorological Laboratory/NOAA

Hurricanes

Why Can't We Stop Hurricanes?

One of the most commonly asked questions is why we don't try to stop hurricanes from forming or to disrupt them once they do form. It doesn't sound too hard, does it? Well, so far researchers have found it's impossible to do. The federal government, through the National Oceanic and Atmospheric Administration (NOAA) tried various inventions to weaken hurricanes, but gave up in the 1960s. The weather systems that make up hurricanes are too large to affect. Now NOAA researchers focus on trying to better understand how hurricanes form and move.

In 1955, Congress funded the National Hurricane Research Project to conduct research into these dangerous storm systems. In 1960, researchers acquired two DC6 airplanes to use just for hurricane research. Improved computers and the regular flights of the "Hurricane Hunter" planes helped meteorologists (scientists who study weather) to learn more and more about hurricanes. Over time, the forecasts and project "track" of hurricanes has gotten more and more accurate.

Some of the successes achieved by NOAA researchers include:

Studying the success of a Stepped-Frequency Microwave Radiometer, carried aboard a Hurricane Hunter plane, to map a hurricane.

Designing satellite-based modems for transmitting information from the Hurricane Hunter plans to computers on the ground to speed up the transfer of the data.

Improving forecasting so that the future track of hurricanes is more accurate - very important to knowing where a hurricane will hit and if a particular community needs to evacuate.

Developing a "Global Positioning System Dropwindsonde" to take measurements in the inner core of hurricanes to improve analysis and forecasts.

Information courtesy of the Hurricane Research Division of the Atlantic Oceanographic and Meteorological Laboratory/NOAA

Test Your Hurricane Knowledge

Click the Yes or No box for each name to mark whether or not you think that name was ever used for a hurricane or tropical storm.

Andrew	○ Yes	○ No	Agatha	○ Yes	○ No	Bertha	○ Yes	○ No
Betsy	○ Yes	○ No	Bonnie	○ Yes	○ No	Camille	○ Yes	○ No
Charley	○ Yes	○ No	Delta	○ Yes	○ No	Erin	○ Yes	○ No
Floyd	○ Yes	○ No	Frances	○ Yes	○ No	Garth	○ Yes	○ No
Helene	○ Yes	○ No	Hortense	○ Yes	○ No	Holly	○ Yes	○ No
Jack O'Lantern	○ Yes	○ No	Larry	○ Yes	○ No	Marilyn	○ Yes	○ No
Olga	○ Yes	○ No	Opal	○ Yes	○ No	Quinn	○ Yes	○ No
Sally	○ Yes	○ No	Timothy	○ Yes	○ No	Uma	○ Yes	○ No
Wilma	○ Yes	○ No	Yancy	○ Yes	○ No	Zelda	○ Yes	○ No

Get My Score

Do you want a hint? | Want another hint? | Want another hint? | Do you want the answers?

FEMA for Kids

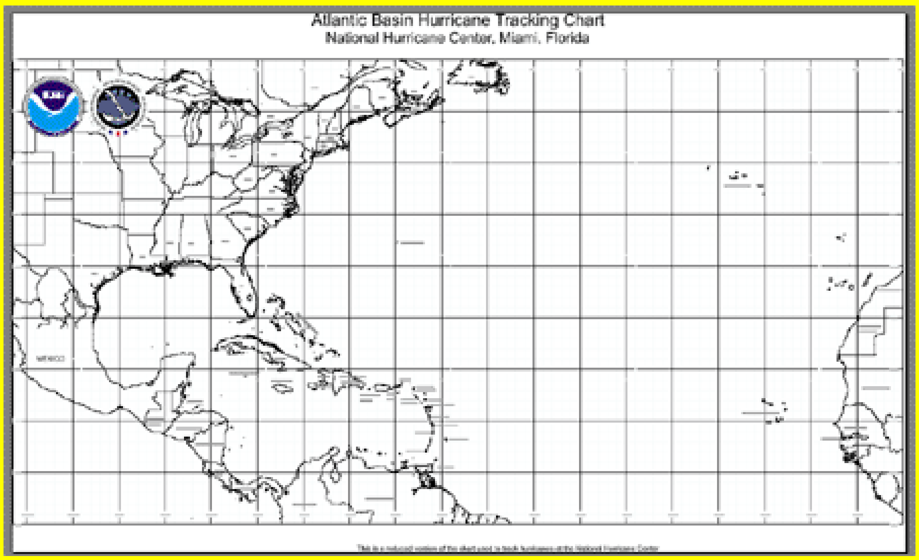
Federal Emergency Management Agency

How To Track A Hurricane

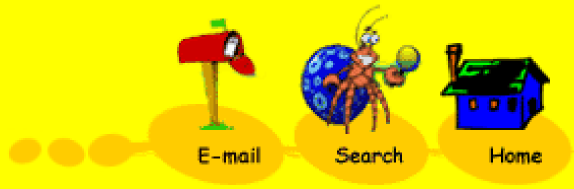
The National Hurricane Center, which is part of the National Weather Service and the National Oceanic and Atmospheric Administration, tracks tropical storms and hurricanes.

Hurricane watches and warnings are issued when the storms get close to the U.S. You can track the progress of storms by listening to the coordinates given by your television meteorologists. Or you can regularly check on http://www.nhc.noaa.gov/ for the latest longitude and latitude locations issued by the National Hurricane Center.

You can print out this tracking map or download the Tracking Map PDF (906 KB) to make your own tracking maps. (You will need the Adobe Acrobat Reader) Where do you think the storms will go?



Hurricanes



Hurricane Classification

Hurricanes are classified into five categories, based on their wind speeds and potential to cause damage.

- Category One -- Winds 74-95 miles per hour
- Category Two -- Winds 96-110 miles per hour
- Category Three -- Winds 111-130 miles per hour
- Category Four -- Winds 131-155 miles per hour
- Category Five -- Winds greater than 155 miles per hour

In the U.S., the official hurricane season is from June 1 to November 30, but hurricanes can happen any time of the year. Hurricanes are named by the National Weather Service. Some past hurricanes have been named: Opal, Andrew, Marilyn, Hugo and Fran.

Important terms to know:

Hurricane Watch -- A hurricane is possible within 36 hours. Stay tuned to the radio and television for more information. The Hurricane Center is tracking the storm and trying to predict where it may come ashore.

Hurricane Warning -- A hurricane is expected within 24 hours. You may be told to evacuate. You and your family should begin making preparations to evacuate. If your area is having an evacuation, remember to take your Disaster Supply Kit. Do not forget to make plans for your pets if you must evacuate.

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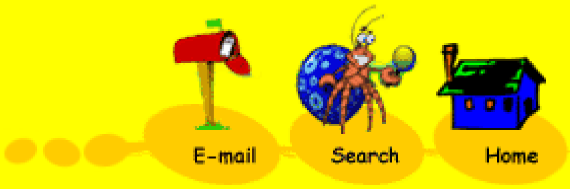
Hurricanes



A History Of Big Hurricanes

Hurricane Carla: This hurricane hit on September 10, 1961. It struck the Texas coast. About 500,000 people were evacuated from the area. Winds near the center of the hurricane were estimated at 150 miles per hour. Damage was about $2 billion (adjusted to 1990 dollars) and 46 people died.

Hurricane Betsy: This hurricane hit on September 8, 1965. It hit Florida first and then turned and hit the Louisiana coast. A total of 75 people lost their lives. The hurricane had winds as high as 160 miles per hour. In 1990 dollars, Betsy caused $6.5 billion of damage -- making it the third most costly hurricane in the U.S.

Hurricane Camille: This hurricane began on August 17, 1969. It was a Category 5 hurricane -- the most powerful rating, with winds as high as 200 miles per hour. The hurricane hit the U.S. Gulf Coast, but also caused flooding in Virginia. About 250 people died because of the hurricane and the flooding. It was the fifth most costly disaster in U.S. history, with damage of $5.2 billion (in 1990 dollars).

Hurricane Celia: This hurricane hit Texas on August 3, 1970 and caused $1.6 billion in damage (in 1990 dollars). Very high winds damaged an airport and demolished a nearby mobile home park, fortunately, only 11 people died.

Hurricane Gilbert: This hurricane hit on September 16, 1988. It was a Category 5 hurricane with winds as high as 160 miles per hour. It went through Jamaica, over the Yucatan peninsula of Mexico and came to the U.S. (Texas and Oklahoma) as a heavy rain storm. Damage in Mexico was many billions of dollars, and 318 people died.

Hurricane Andrew: This hurricane hit on August 24, 1992 in southern Florida. It then turned and hit Louisiana. More than a million people had to leave the area due to the storm. Heavy rains and tornadoes were part of the hurricane’s destructive power. Andrew was the most expensive hurricane in the history of the U.S.

Hurricane Floyd: This hurricane, which struck in September 1999, brought so much rain that 13 states were issued federal disaster declarations -- more declarations for a single event than ever before. More than $500 million of federal money was spent on helping states recover. North Carolina was hit the hardest of any state.

Hurricane Classification

Information courtesy of The National Hurricane Center

FEMA for Kids — Federal Emergency Management Agency

Hurricanes

Hurricane Names

All hurricanes are given names. Why is that? To help us identify storms and track them as they move across the ocean. Remember, there can be more than one hurricane at a time and without naming them, we could get confused and which storm we're talking about.

For hundreds of year, hurricanes in the West Indies were named after the particular saint's day on which the hurricane occurred. An Australian meteorologist began giving women's names to tropical storms before the end of the 19th century. In 1953, the U.S. National Weather Service, which is the federal agency that tracks hurricanes and issues warnings and watches, began using female names for storms.

In 1979, both women and men's names were used. One name for each letter of the alphabet is selected, except for Q, U and Z. For Atlantic Ocean hurricanes, the names may be French, Spanish or English, since these are the major languages bordering the Atlantic Ocean where the storm occur.

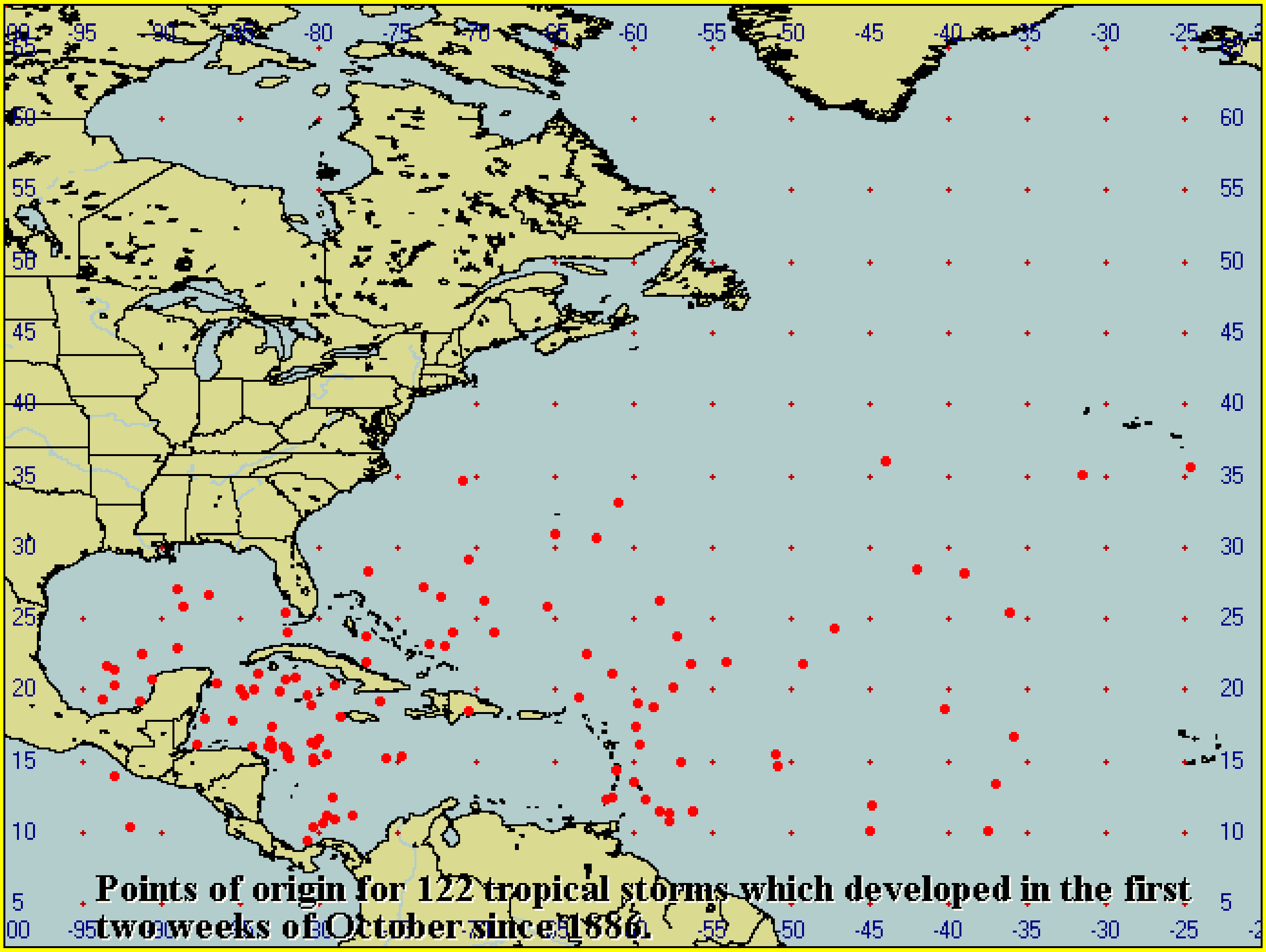
So who decides what names are used each year? The World Meteorological Organization uses six lists in rotation. The same lists are reused every six years. The only time a new name is added is if a hurricane is very deadly or costly. Then the name is retired and a new name is chosen.

- Atlantic Hurricane Names
- Pacific Hurricane Names
- Retired Hurricane Names

National Hurricane Center

Hurricanes

Points Of Origin For South Atlantic Hurricanes In The Last 100 Years



Caption: Points of origin for 122 tropical storms which developed in the first two weeks of October since 1886.

Hurricane Cartoons

"Ow! I have something in my eye!"

Caption: OW! I have something in my eye! Don't you hate those pesky Hurricane Hunter planes? © 1996 Katie Sullivan

Special planes called "Hurricane Hunters" fly into hurricanes to gather valuable information. The people on the airplanes belong to the Air Force Reserve. In the eye of the hurricane, they can measure wind speed, air pressure and the structure of the storm.

More Cartoons

Bio: Weather enthusiast Katie Sullivan is the artist behind this collection of cartoon and explanations. The Wisconsin high school senior has yet to experience a hurricane firsthand, but has been fascinated by these awesome storms since 1991. Hoping to become a tropical meteorologist and novelist, Katie's interests include writing, drawing, postcard collecting, computers, and, of course, weather.

Federal Emergency Management Agency

Disaster Math

Hurricane A has winds that are moving at 124 miles per hour on Sunday. On Monday, Hurricane A''s winds have slowed down and are only going 94 miles per hour. What is the difference in the speed of the winds from Sunday to Monday?

- 218 miles per hour
- 30 miles per hour
- 1,000 miles per hour
- 1 miles per hour

Tropical storms officially become hurricanes when they reach 74 miles per hour. Tropical Storm Z currently has winds of 59 miles per hour. How much do the winds of Tropical Storm Z need to speed up in order for the storm to become a hurricane?

- 133 miles per hour
- 13 miles per hour
- 15 miles per hour
- 51 miles per hour

Hurricanes can cause storm surge - when the water of the ocean rises much higher than usual. Storm surge is very dangerous, and can sweep away homes that are built right along the beach. In the town of Palm Nut Beach, the homes along the water are built on stilts that are 8 1/2 feet high. If the storm surge is 6 1/4 feet high, how much space is there between the homes and the water?

- 2 1/4 feet
- 5 feet
- 10 feet
- 1 1/4 feet

Pretend that the storm surge is 10 1/2 feet. How much of the house would be under water?

- 5 feet
- 1 foot
- 22 feet
- 2 feet

There is a hurricane warning for the coast and three towns might have to evacuate: Palm Nut Beach (population 3,451), Femaville (population 1,256)

and Sandgate (population 7,436). What is the total number of people who might have to evacuate from these three towns?

- 12,143 people
- 1,243 people
- 14,123 people
- 21,431 people

There are 1,200 houses in Palm Nut Beach. The town has been told to prepare for a hurricane by storing water. Each household is told to store 12 gallons of water. How many gallons of water will the town store?

- 4,000 gallons
- 14,400 gallons
- 12 gallons
- 1,200 gallons

Get My Score

FEMA for Kids

Federal Emergency Management Agency

Hurricane House

E-mail Search Home

In the event of a hurricane, you should prepare your yard for the worst. In the image below, click on all objects which may cause a problem during a hurricane.

The game you are trying to access requires the use of a Java-enabled browser. The browser you are using is not Java enabled. Please refer to our help page for more information about recommended browsers.

FEMA for Kids

Federal Emergency Management Agency

Video Library

These video clips can be viewed using the Real Media Player or Windows Media Player.. Download the free version of Real Media Player or Download the free version of Windows Media Player

These files may take some time to load, please be patient.

Earthquake Drill

Earthquake Drill - Windows Media File -- 2.6 MB

A Public Service Announcement created by students at Furgeson Academy of Communication and Technology, in Hawaiian Gardens, Ca.

Fire Drill

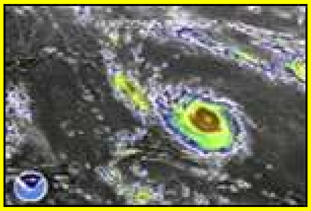
Fire Drill - Windows Media File -- 2.5 MB

A Public Service Announcement created by students at Furgeson Academy of Communication and Technology, in Hawaiian Gardens, Ca.

Pets and Disaster

Real Media File -- 916 KB

Hurricane Andrew Satellite Footage



Real Media File -- 163 KB

Hurricane Andrew Computer Simulation

Real Media File -- 336 KB

Tornado Footage

Real Media File -- 813 KB

FEMA for Kids

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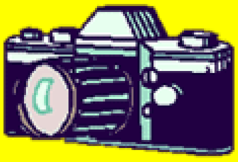


Photos

Hurricane Hunters

It is hard to imagine, but a group of pilots called The Hurricane Hunters actually fly directly into hurricanes! The 53rd Weather Reconnaissance Squadron, known at the Hurricane Hunters, are part of the Air Force Reserve. They fly right into the eye of the hurricane to get information on the hurricane. This information is used by the National Hurricane Center to make predictions about the size, strength and future path of the hurricane. This information, in turn, is used by local officials who need to make decisions about possible evacuations of areas that might be at risk for the hurricane.

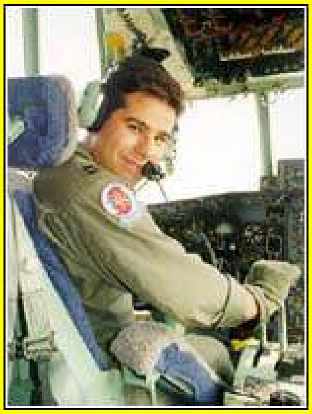
The Hurricane Hunters use WC-130 aircraft on their weather missions. The planes have a six-person crew that includes the aircraft commander, co-pilot, flight engineer, navigator, weather officer and a dropsonde system operator. The dropsonde system operator releases the dropsonde - a weather-sensing canister attached to a small parachute. This canister radios back to the aircraft information on the temperature, humidity, pressure and winds inside the storm. The weather information is processed aboard the aircraft and transmitted by satellite to the National Hurricane Center.

The first mission to check a new hurricane is flown at a low-level altitude, generally between 500 and 1,500 feet. Later, as the storm builds in strength, the flights are at higher altitudes. The planes fly right into the storm - not above it! The ride can get pretty bumpy as the area around the eye is usually surrounded by a solid ring of thunderstorms called the eyewall. Sometimes the clouds and rain are so thick the aircraft's wings are barely visible to the crew.

Please click on image to view larger size and caption.








Hurricanes

The Story Of Mary Ann And Hurricane Camille

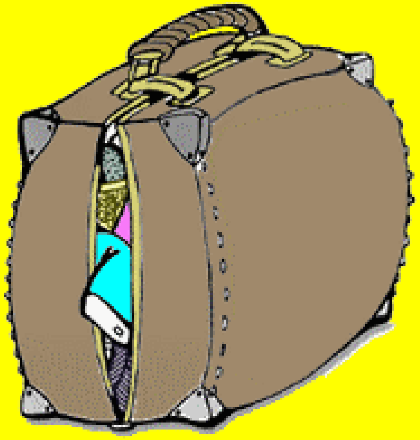
Mary Ann lived near the Gulf of Mexico in 1969 when Hurricane Camille struck her three-story apartment building. Mary Ann was one of 24 people who didn't leave the Richelieu Apartments when they were warned. When the storm surge hit, the building began to creak and the windows broke out. Water started flooding in and was all over the apartment in a matter of two minutes - and the apartment was on the second floor!

In about five minutes, Mary Ann's bed was floating half way to the ceiling. As the building began to fall apart, Mary Ann floated out of the window and grabbed onto a sofa pillow that came by. She became tangled in wires and debris. It was dark, but Mary Ann saw the building come down all around her. The wind was awful. It reached 234 miles per hour during Hurricane Camille. Mary Ann continued to hold onto anything she could-furniture, tree limbs and parts of houses and buildings. The winds and waves were so strong that every time Mary Ann grabbed hold of something it would be ripped from her hands. She kept getting hit by the wreckage and was bloody from head to toe from the nails in the boards. This went on for 12 hours before Mary Ann was found 4 ½ miles from her house. She was taken to a hospital where she stayed for three weeks.

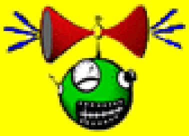
Today, Mary Ann is grown up. She still lives in Mississippi. She tells her story over and over so people will listen when they're told to evacuate.

Hurricanes

- Listen to a radio or television for weather updates and stay in touch with your neighbors about evacuation orders.
- Plan a place to meet your family in case you are separated during a disaster. Choose a friend or relative out of state for your family members to call to say they are OK.
- Assemble your disaster supplies kit. Store extra water now! Check to make sure you have enough food.
- Storm shutters are the best protection for windows. If your house does not have them, help an adult board up windows with 5/8" marine plywood. Tape does NOT prevent windows from breaking!
- Bring in outside furniture. An adult should remove roof antennas, if they can do so safely.
- Help an adult shut off your utilities -- water, electricity and gas.
- Make sure there is gas in the car and you are ready to evacuate immediately, if you are told to do so.
- If you don't need to evacuate, be sure to STAY INDOORS during a hurricane. You could be hit by flying objects. Don't be fooled if there is a pause in the wind. It could be the eye of the storm, and the winds will come again.
- Avoid using the phone except for an emergency so the phone lines can stay open for others.
- If you do evacuate, do NOT go back home until local officials say it is safe.
- Hurricanes can be very scary. If you are scared, be sure to talk to someone about it.



It's Hurricane Season



Audio

Julia and Robbie's mother sighed as she packed the last of their clothes. She pushed down on the suitcase to make it close and she snapped the latch.

"I'm almost afraid to plan a vacation," she said. "You two *are* Double Trouble."

"Don't be mad at us," Julia pleaded.

"It wasn't our fault there was an earthquake when we visited Uncle James," said Robbie. He was eating a peanut butter sandwich and he talked with his mouth full. Julia giggled.

"And it wasn't our fault that the Acorn River flooded when we visited Grandma," said Julia.

"Of course it wasn't your fault and I'm not mad," their mother said. She leaned down and wiped the crumbs from Robbie's mouth. "But everywhere you go something seems to happen."

Julia nodded. She knew it was true. In addition to the earthquake and the flood, a tornado had nearly hit their town.

"But this time will be different," said Julia.

"I can't wait to see what Florida looks like," said Robbie.

It was a long drive to Florida and their father kept them busy by asking them hurricane questions. The twins had studied hurricanes at school.

NEXT PAGE >>

Photos

E-mail Search Home

Hurricane Photos

Please click on an image for a larger view and caption.





FEMA for Kids

Federal Emergency Management Agency

Inondations

Que faire avant et après ?

Outre le triste bilan en vies et en souffrances humaines, les dommages causés par les inondations coûtent aux contribuables canadiens des millions de dollars par année.

Les divers ordres de gouvernement s'appliquent à réduire les risques d'inondations, mais la sécurité personnelle repose d'abord et avant tout sur les épaules de l'individu. Il incombe à chacun de nous de tout mettre en oeuvre pour protéger les membres de notre famille et notre demeure. Vous pouvez faire votre part pour réduire les dommages causés par les inondations; il suffit de planifier en conséquence et de prendre quelques sages précautions.

Il y a plus d'une façon de prévoir les dangers d'inondations qui menacent certaines régions, notamment :

- la surveillance de la crue des eaux à la suite de pluies abondantes;
- l'étude de l'enneigement dans les bassins versants des rivières;
- les observations et les prévisions météorologiques.

Les crues-éclair, ou soudaines, qui ne laissent que très peu de temps pour avertir la population, peuvent également être causées par des tremblements de terre, des tsunamis, ou raz de marée, des ouragans, des tempêtes ou des ruptures de barrages.

Dans toutes ces circonstances, les autorités locales tenteront de renseigner la population sur l'évolution de la situation dans les régions les plus susceptibles d'être inondées. Des bulletins d'information apporteront régulièrement des précisions sur les mesures que les gens doivent prendre pour limiter ou prévenir le désastre. Au besoin, les autorités municipales ou provinciales donneront des directives plus précises.

ABOUT CMHC

CMHC-SCHL

- CMHC's Mission and Values
- The four pillars of CMHC service to Canadians
- Careers at CMHC
- Doing Business with CMHC
- Annual Report
- CMHC's Corporate Plan (summary)
- Minister and Directors
- CMHC's Board of Directors
- A History of CMHC
- The National Housing Act

Canada

IN YOUR REGION

CMHC SCHL

Atlantic

Québec

Ontario

Prairies, Nunavut & Northwest Territories

British Columbia and Yukon

FREQUENTLY ASKED QUESTIONS

CMHC SCHL

Frequently Asked Questions

- Renovation
- General
- Mortgage Backed Securities
- Affordable Housing

Canada

Browse by topic

- Buying or renting a home
- Building, renovating & maintaining
- Mortgage insurance & investments
- Programs & financial assistance
- Housing markets, domestic & international
- Improving quality & affordability

Shortcuts for...

- Individual consumer
- Aboriginal
- Housing industry professional
- Mortgage lender/broker
- Investor
- Researcher

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- Access CMHC
- Reference and Research Services
- Information Request
- Current Housing Research
- Links to Other Sites

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News Releases — most recent, plus archives sorted by date and keyword

Information Request — an email form

Awards & Recognition

Story Ideas

Speeches and Backgrounders

Annual Report — most recent, plus archives

CMHC's Board of Directors

Minister responsible for CMHC

Corporate Plan (summary)

Federal, Provincial and Territorial Agreements on Affordable Housing

Canada

Contact Us

If you are unable to find information you need on the Web site, please contact the appropriate department or division of CMHC. Please carefully review the selections below, to ensure your question is directed to the correct department.

Frequently Asked Questions — the answer to your question may be just a click away

Ordering Publications

National Office — main address, administration contact numbers, location map

Regional Offices — addresses, contact numbers and maps for locations across Canada

Assisted Housing — information on financial assistance and social housing programs

CMHC International — information for Canadian exporters, and about CMHC services to other countries

Market Analysts — for data, statistics and analysis about housing markets across Canada

Mortgage Loan Insurance — contacts across Canada. For information related to your own mortgage, you should first contact your lender.

Canadian Housing Information Centre — for research and library services focused on housing.

General Inquiries — if unable to identify a contact above. Please review the FAQs section before submitting.

The Home Buyers Plan allows you to withdraw money from your RRSPs to build or buy a home. For questions, contact a Canada Revenue Agency service office.

Webmaster — to submit problems reports or comments related to the functioning of the Web site. Program or product related questions should be submitted to the correct department from the list above.

Minister responsible for CMHC

Government Employee Directory — to find telephone numbers of CMHC employees

Regional Offices:

Atlantic Provinces:

- **Business Centre, Halifax**
- Charlottetown
- Fredericton
- St. John's
- Moncton

Québec:

- **Business Centre, Montréal**
- Chicoutimi
- Gatineau
- Québec
- Sherbrooke

Ontario:

- **Business Centre, Toronto**
- Hamilton
- London
- Ottawa
- Sudbury
- Thunder Bay

Prairie, Nunavut and Northwest Territories:

- **Business Centre, Calgary**
- Edmonton
- Regina
- Winnipeg
- Yellowknife
- Saskatoon

British Columbia and Yukon:

- **Business Centre, Vancouver**
- Granville Island Project Office
- Victoria
- Whitehorse

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WELCOME TO CMHC

HOME TO CANADIANS

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- Mortgage lender/broker
- Investor
- Researcher

Step Through the Life-Cycle of Your Home

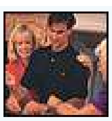
FLASH ANIMATION

Over your lifetime, your needs and preferences will change. From finding the right home to making renovations, CMHC can help make sure your home grows with you. Explore the possibilities!

Canada Mortgage and Housing Corporation

"Sunsnine on the water looks so lovely"

This line from John Denver's popular song of 1974 fits right in with relaxed mid-summer days, but when that water is in your basement, it's anything but lovely. Learn how to prevent basement flooding with our new fact sheet, and if you have suffered from flooding, click here for advice. Speaking of summer, take a look at how you can personally contribute to a cooler planet, by reducing energy consumption. If you're spending your summer getting ready to move, we can help with that, and also with making healthy choices in your next, or current house. Enjoy the rest of summer with CMHC's help.



Renovating Your Kitchen

The kitchen is often the most used room in the house and kitchen renovations typically have the highest financial payback. Conduct a pre-renovation inspection and prioritize the most desirable features for your new kitchen.

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ORDER DESK

Order CMHC Products

Events Calendar

Aug. 2004

Su	Mo	Tu	We	Th	Fr	Sa
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8	9	10	11	12	13	14
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22	23	24	25	26	27	28
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Today is: Aug. 29, 2004

FEATURED EVENT:

Seabird Island First Nation Sustainable Community Demonstration Project Tours

Sep. 16

CMHC's newest flagship publication, the Canadian Housing Observer, presents a comprehensive overview of Canadian housing conditions, trends and key factors behind them.

[Repairing or Replacing Roof Finishes]

Regular maintenance and periodic roof inspections will identify problems before they cause costly damage to your home. Learn about the key factors that will determine whether you should repair or replace your roof.

[Measuring Humidity in Your Home]

We need humidity for our comfort and health. But too much or too little humidity can produce a host of difficulties for householders.

[Landscape Guide for Canadian Homes]

Perhaps the ultimate landscape book for Canadian homeowners — learn about low-maintenance gardens and lawns, water conservation, natural pest control methods, even how to hire a landscape contractor.

[Water Damage, Mold, and House Insurance]

When homeowners have flooding damage due to a plumbing leak or a summer storm, this document will instruct them on how to deal with the insurance company and how to hire a restoration contractor.

[Choosing a Dehumidifier]

Air that is too damp can cause condensation on windows, water damage to materials, mold and even wood rot. Choose the right dehumidifier to regulate the humidity in your home.

News Releases

Housing starts remain at high level
August 10, 2004

Starts will Reach 17 Year High in 2004
August 4, 2004

Housing Starts Remain High in June
July 9, 2004

Housing Starts Remain High In May
June 8, 2004

Affordable Housing Conditions Improve Across Canada
May 21, 2004

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- Programs & financial assistance
- Housing markets, domestic & international
- Improving quality & affordability

Shortcuts for...
- Individual consumer
- Aboriginal
- Housing industry professional
- Mortgage lender/broker
- Investor
- Researcher

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Buying or Renting a Home

Buying a Home
A step-by-step outline of the homebuying process, information about financing and mortgages, and useful tools and publications

Mortgage Loan Insurance
CMHC's mortgage loan insurance allows Canadians to purchase a home with a downpayment as low as 5%.

Housing Market Information
Information to help you understand housing markets and trends.

Building and Design
Building and construction techniques and concepts, and housing design options to meet special needs.

Renting a Home
Information on market vacancy and rental rates, finding rental accommodation and assistance to repair rental properties.

On Reserve Housing
Programs and services to meet the housing needs of Aboriginal Canadians living on reserve.

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UILDING, RENOVATING & MAINTAINING

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Building, Renovating & Maintaining

Self-Help and Problem Solving
Fact sheets and self-help information on common questions, issues and problems in your home.

Renovation Planning
Fact sheets, videos and information to help you plan a renovation project, and related publications.

Renovation / Adaptation Assistance Programs
Assistance programs available to repair, renovate or adapt housing for low-income Canadians.

Building and Design
Building and construction techniques and concepts, and housing design options to meet special needs.

Highrises & Multiples
Best practice guides and technical fact sheets for the construction, operation, maintenance and repair of multi-unit residential buildings.

On-Reserve Options
Programs and services available on reserve.

Coping with Emergencies
Advice on dealing with floods, power outages and storm damage.

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Mortgage Insurance & Investments

Mortgage Insurance for Borrowers
Information on eligibility, premiums, terms and conditions related to CMHC mortgage loan insurance.

Mortgage Insurance for Lenders
Information for mortgage lenders and brokers to help them efficiently transact loan insurance business with CMHC.

Mortgage-Backed Securities
Information about investing in Canadian residential mortgages.

CMHC Debt Securities
CMHC borrows to provide mortgage loans for social housing projects.

Properties for sale
Listings of multi-unit residential properties for sale through real estate agents and CMHC.

Canada Mortgage Bonds (CMB)
An investment opportunity that helps ensure affordable mortgage funds are available to Canadians.

Programs & Financial Assistance

Aboriginal Housing
Programs and services to meet the housing needs of Aboriginal Canadians.

Residential Rehabilitation Assistance Program (RRAP)
RRAP programs help low-income Canadians, people with disabilities and Aboriginal Canadians live in decent, affordable housing.

Home Adaptations for Seniors' Independence
An assistance program for making minor home adaptations to extend the time low-income seniors can live in their own homes.

Other Assistance Programs
Programs to help preserve or increase the supply and availability of affordable housing.

Centre for Public-Private Partnerships in Housing
A CMHC group that works with government agencies and non-profit community groups on affordable housing development.

Grants and Awards
Grants, awards and funding programs encouraging innovative ideas and research to address the housing needs of Canadians.

Find out more!

More Affordable Housing for Canadians!

HOUSING MARKETS, DOMESTIC & INTERNATIONAL

CMHC SCHL

Housing Markets, Domestic & International

Market Trends and Statistics
Information on historical and recent housing market performance as well as forecasts and analysis of local, regional and national housing trends.

Factors Affecting the Housing Industry in Canada
Publications include best practices in design and development, urban planning and social and community housing.

Exporting Canadian Products & Expertise
CMHC supports export opportunities for Canadian manufacturers and building technologies, and promotes our expertise in developing standards, policy and housing finance systems.

Canada

Improving Quality & Affordability

Affordable Housing
Projects, ideas and programs aimed at making affordable housing available to Canadians.

Healthy Housing & Sustainability
Concepts for making your home healthier for you and the environment, and planning for sustainable communities.

FlexHousing™
An innovative construction and design concept, a FlexHouse has the ability to adapt to changing housing needs through all stages in life.

Highrises and Multiples
Best practice guides and technical fact sheets for the construction, operation, maintenance and repair of multi-unit residential buildings.

Homelessness
Discussion groups, literature reviews and information on initiatives related to homelessness.

AN INDIVIDUAL CONSUMER

CMHC SCHL

CMHC has information products to help you make important decisions about your home. From home-buying guides to mortgage insurance to renovation planning, CMHC is your one-stop shop for housing information.

- Homeowner or Landlord
- Renter
- Home Buyers or Property Investor
- Senior
- Person with disabilities
- Job Seekers

Step Through the Life-Cycle of Your Home

Step Through the Life-Cycle of Your Home

Canada

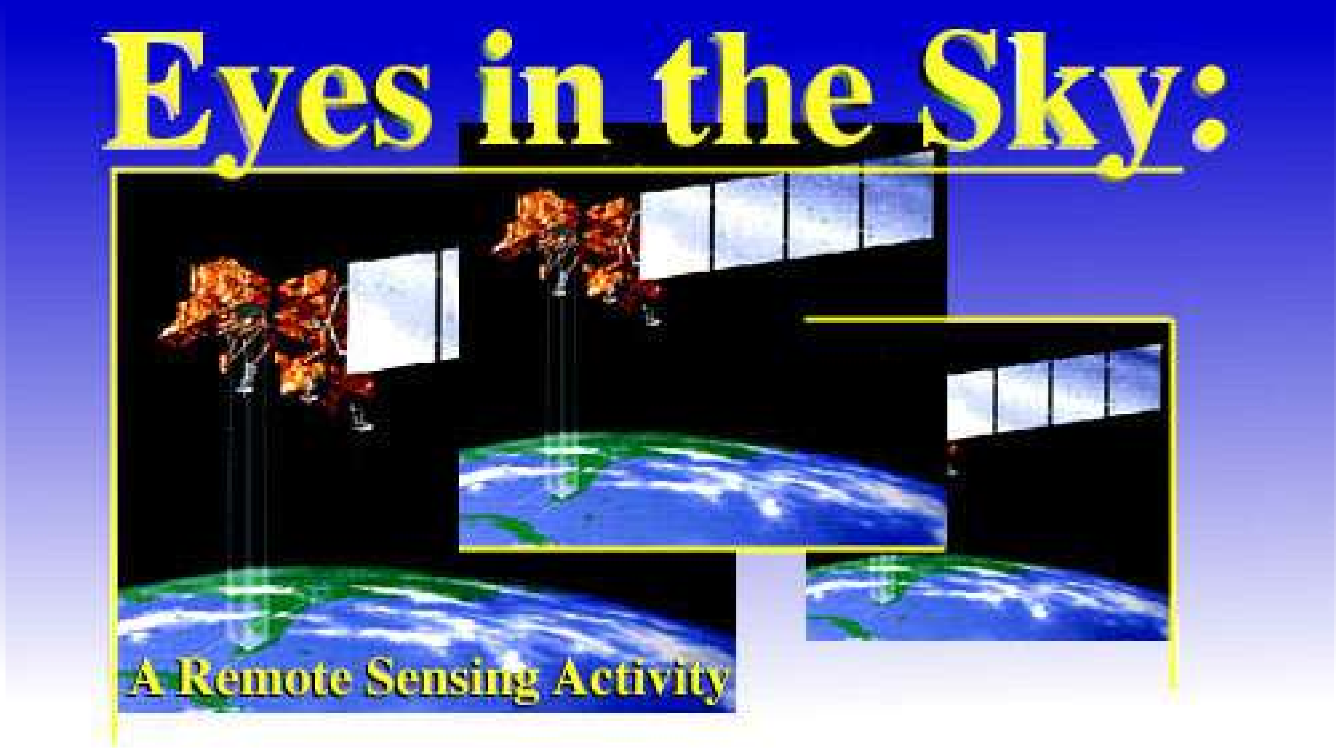
Just Doing My Job

The Mississippi Flood of 93.

Lee Blackmore was finally enjoying an early morning cup of coffee when the phone rang. A young image analyst and GIS specialist with the St. Louis Community Development Agency (CDA), he had finally managed to grab a few hours of sleep after nearly two days in front of his computer producing maps and images of the flooded Mississippi River. On the phone was an emergency coordinator from the police department. "Lee," the voice said, "we need your help."

Begin

HOME



[Begin]

[Back to Educator's Resources]

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NASA's Observatorium

Just Doing My Job

The Mississippi Flood Of 93

1. Lee Blackmore worked for which of the following agencies?

- ◯ CDC
- ◯ IRS
- ◯ CNBC
- ◯ Army Corps of Engineers

2. According to the article, during the spring and summer of 1993, which of the following rivers did NOT flood?

- ◯ Mississippi
- ◯ Missouri
- ◯ Colorado
- ◯ Illinois

3. Which type of image was used by Blackmore to locate areas in danger of flooding?

- ◯ Camera photographs
- ◯ Satellite images
- ◯ Video images
- ◯ Graphic images

4. Why didn't the police want to evacuate everyone from the area?

- ◯ They were too lazy.
- ◯ There wasn't enough time.
- ◯ They didn't have the budget or resources.
- ◯ Both b and c.

5. How did Lee Blackmore and the CDC decide who was in the most danger?

- ◯ They drew names from a hat.
- ◯ They electronically superimposed a digital map of the river boundaries on a map showing streets and buildings.
- ◯ They consulted a psychic.
- ◯ They never really knew, they just did their best guessing.

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Just Doing My Job

The Mississippi Flood of 93.

Teachers, check out the Flood: Just Doing my Job teacher's guide.

For additional information on the use of remote sensing in emergency management, check out the following sites:

Flood Management Enhancement Using Remotely Sensed Data

http://www.sentar.com/NASA/

The Great Flood of Summer 1993: Mississippi River Discharge Studies

http://www.agu.org/sci_soc/walker.html

The SAST Database: An Environmental Information System for the Upper Mississippi and Lower Missouri River Basins

http://edcwww2.cr.usgs.gov/sast-home.html

The flood photos used here were obtained from the Federal Emergency Management Agency (FEMA).

http://www.fema.gov/library/mw.htm

Other images related to emergency management are also available from the FEMA Photo Library.

http://www.fema.gov/library/photo.htm

The shuttle image is one of many in the Johnson Space Center image collection.

http://images.jsc.nasa.gov/

Shuttle radar images are at JPL.

http://www.jpl.nasa.gov/sircxsar/rivers.html

Other images may be obtained through NASA.

http://ltpwww.gsfc.nasa.gov/ndrd/gallery.html

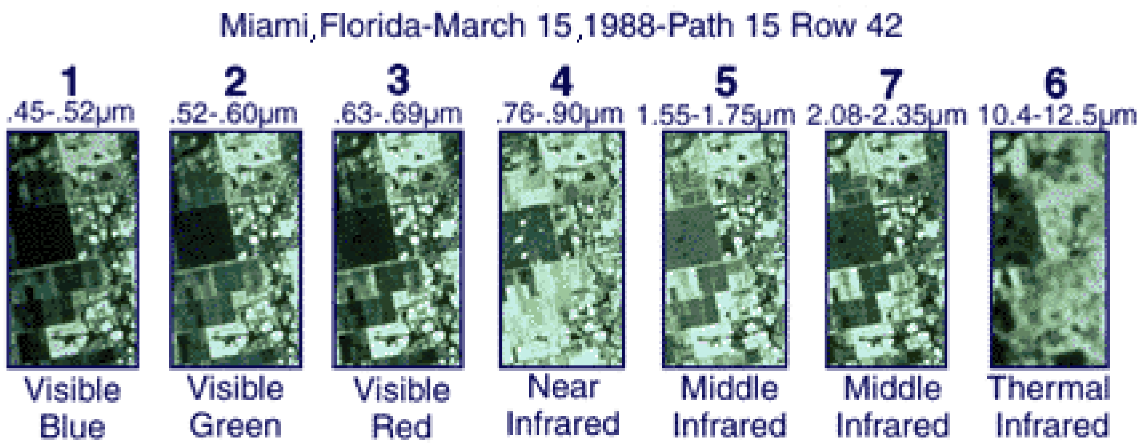
These links will lead you to many more interesting sites. Most contain images you can download.

We thank the City of St. Louis Community Development Agency and Mr. Lee Blackmore for all their help.

http://stlouis.missouri.org/development/orgs/cda/

Landsat's Thematic Mapper Bands

The multispectral remote sensing instruments carried on the Landsat and other satellites measure the amount of energy reflected and emitted in several discrete portions, or bands, of the EM spectrum. The various visible and infrared bands were chosen to measure reflected and emitted energy in areas of the spectrum that correspond to known responses of the target materials. These include specific characteristics of land, vegetation, water, rocks, and temperature.



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NASA's Observatorium
Just Doing My Job
The Mississippi Flood Of 93

Welcome to the Flood Wordsearch page. As you look for the hidden words, remember that they can be horizontal, vertical, or diagonal -- frontward or backward! Once you've found a word, simply click on the first letter and drag to the last. For a new puzzle, hit the restart button. Good luck!

Back to Wordsearches
Back to Flood

HOME

NASA'S OBSERVATORIUM TEACHER'S GUIDES

Welcome to the Observatorium's teacher's guides. We realize how busy teachers can get, and we know that with all the information on the Web it can be hard to read the articles and apply them to the classroom. Therefore, we've decided to give teachers a helping hand.

A teacher's guide has been developed to accompany each article in the Observatorium. These guides are very basic, providing teachers with a start in the right direction. We encourage educators to print the guides and use them in the classroom or at home. Happy teaching!

Aeronautics

- Astronomy for the Jet Set
- ER-2: High Flying Science NEW
- See How Planes Fly
- SR-71: Speed in the Service of Science NEW
- Wind Tunnels

Planet Earth

- Earth -- The Ever-Changing Planet
- El Niño
- Flood: Just Doing My Job
- Impact Craters
- Million Man March
- Ozone
- Plate Tectonics
- Remote Sensing in History
- Seasons
- Spy!
- Tsunami: The Big Wave
- Ubar: The Lost City

Space Science

- Cassini: Mission to Saturn
- Lunar Prospector
- Our Sun
- Stars--An Introduction
- Ulysses Plays Billiards

Back to Educator's Resources

HOME

NASA's Observatorium is a public access site for Earth and space data. We have pictures of the Earth, planets, stars, and other cool stuff, as well as the stories behind those images.

Bookmark the new: Observatorium URL

Looking for Deep Space Distance Learning Course?

- Aeronautics
- Educator's Resources
- Fun & Games
- Image Gallery
- Planet Earth
- Spaceflight
- Space Science
- FAQ

New Features

- Geospatial Analysis
- Hurricanes (Shockwave required.)
- Wind Chill
- Teacher's Guides

Observation of the Week
Observers Capture Mars Closest Approach

Observation of the Week Archive

This site is currently an archive as of the conclusion of the RSPAC CAN 12/99.

The Observatorium: A cooperative project among NASA's LTP, BDM International, and WVU
Credits: Team, Awards, Link to NASA's Observatorium

June 15, 2001 - This is an archived site maintained by NASA LTP - Privacy Policy. *This site was* *created and archived before ADA Section 508 compliance was mandatory.*

Direct to People!

Today's Story:

The Pathway Less Traveled

This story is available in audio.

August 27: Altered gravity plays an unexpected role in obesity and weight loss.

SCIENTIFIC INQUIRY
Space Science
Astronomy
Living in Space
Earth Science
Biological & Physical Sciences
Beyond Rocketry
SCIENCE RESOURCES
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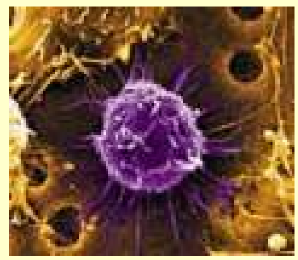
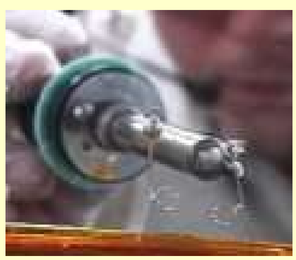
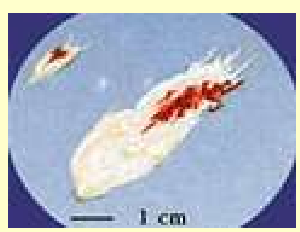
Have Blood, Will Travel - August 19:
fundamental biology
The radiation astronauts encounter in deep space could put vital blood-making cells in jeopardy.

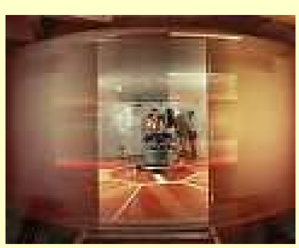




Soldering Surprise - August 16:
space station
There's nothing routine about working in space, as astronaut Mike Fincke found out recently when he did some soldering onboard the International Space Station.

Horseflies and Meteors - August 09:
looking up
Like bugs streaking colorfully down the side window of a moving car, Earthgrazing Perseid meteors could put on a pleasing show after sunset on August 11th.





Spinning Brains - July 23:
living in space
One day, astronauts could zip across the solar system in spinning spaceships. How will their brains adapt to life onboard a twirling home where strange "Coriolis forces" rule?

Our Services

site search

recent stories

July 13: Voyager 1, Prepare for Action- At the outer limits of our solar system, a solar shock wave is about to overtake NASA's Voyager 1 spacecraft.

July 09: Saturn Hailstorm- When Cassini reached Saturn On June 30th, it dashed through a gap in Saturn's rings, twice. One of onboard science instruments r

July 07: Blue Moon- The month of July 2004 has two full moons, which means one of them is a Blue Moon. But will it really be blue? Believe it or not

Production Editor: Dr. Tony Phillips

Curator: Bryan Walls

NASA Official: Ron Koczor

What Neil & Buzz Left on the Moon - July 20:

earth and moon
A cutting-edge Apollo 11 science experiment left behind in the Sea of Tranquility is still running today.

More Stories from Science @ NASA

The Science Directorate at NASA's Marshall Space Flight Center sponsors the Science@NASA web sites. The mission of Science@NASA is to help the public understand how exciting NASA research is and to help NASA scientists fulfill their outreach responsibilities.

July 04: Titan's Surface Revealed- Piercing the smog enshrouding Titan, new images from Cassini reveal an exotic surface covered with a variety of materials.

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science.nasa.gov
Space Science News home

A Swift Look at the Biggest Explosions in the Universe

NASA Selects a Mission to rapidly locate gamma-ray burst sources

Oct. 29, 1999: The story of gamma-ray bursts is becoming like the biography of a film star who hits the jackpot after years of bit parts. Bursts were discovered in the late 1960s by nuclear test detection satellites. Until the 1980s they were monitored by instruments that were piggybacked on satellites designed for other missions.

By then the mystery had led NASA, in 1978, to select the the Burst and Transient Source Experiment (BATSE) as one of four instruments aboard the Compton Gamma Ray Observatory (launched in 1991). BATSE was envisioned as a fire alarm that would notify the other instruments on the observatory to help scientists settle this nagging little mystery.

Right: Artist's concept of the Swift satellite observing a burst. Credit: NASA/Goddard.

In this role, BATSE wins as "best supporting actor" by showing that bursts are perhaps the most violent explosions we can observe in the universe. This has swept up the astrophysics community. More than 3,200 professional papers have been written about bursts, says Dr. Kevin Hurley of the University of California at Berkeley, and papers are being published at the rate of 1.3 per day, faster than bursts are recorded.

As with any star that has made good, the next step is his or her own starring role. That comes in 2003 with the planned launch of Swift. Breaking with NASA tradition, the name isn't an acronym. It describes how quickly the spacecraft is designed to swing around and put an array of telescopes on target and capture bursts before they fade.

Swift will carry three instruments, the Burst Alert Telescope (BAT), an X-Ray Telescope (XRT), and an Ultraviolet/Optical Telescope (UVOT).

The primary mission is quite simple, said Dr. Neil Gehrels, the principal investigator at NASA's Goddard Space Flight Center. He described Swift in the last session (Instrumentation) of the 5th Huntsville Gamma Ray Burst Symposium held in Huntsville, Ala., last week.

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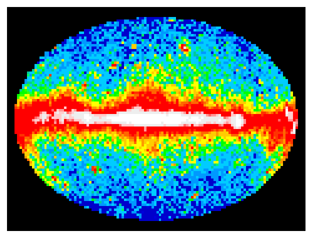
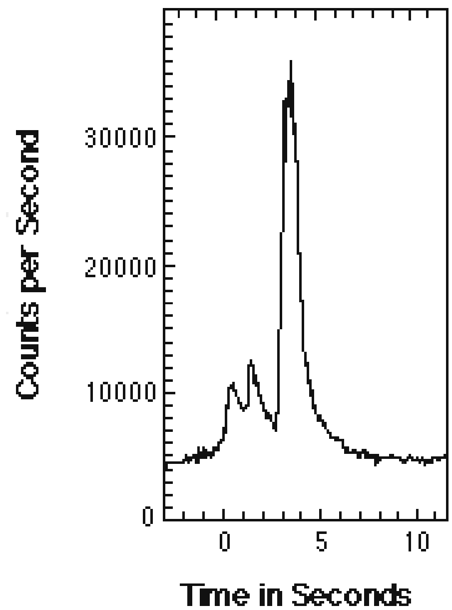
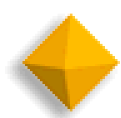




This animation illustrates why bursts are so hard to localize; they come and go like lightning bolts. By the time you're aware that something had happened, it's too late to turn and look at the flash; you can only listen to the echo. (The burster is superimposed on a galactic gamma-ray image.)

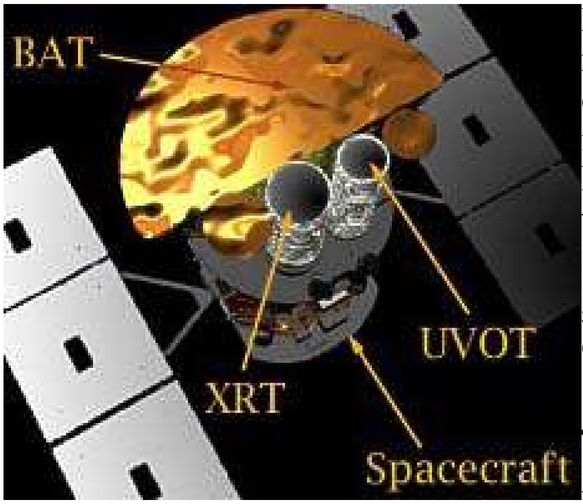


To catch a gamma-ray burst in the act, you need to have instruments already pointed in the right direction. BATSE does this with eight detector modules arranged like the faces of an octahedron so it looks in all directions at once. Its main drawback is resolution; BATSE cannot provide precise locations. Swift will sacrifice all-sky coverage for greater precision. By looking at a large slice of sky with a high-resolution detector, it will provide burst locations fine enough to aim its optical and X-ray telescopes. Credits: NASA/Marshall (left) and NASA/Goddard.

"We know that long bursts are associated with faint galaxies at least halfway to the edge of the known universe," Gehrels said. "But what we don't know is, what are the physical origins of bursts? What are their progenitors [the stars that become bursts] and what is the physics that goes on inside?"

Swift's three instruments will help answer those questions.

First, BAT will detect the onset of a gamma-ray burst. Unlike BATSE, which has eight modules that view the entire sky (other than what the Earth blocks), BAT will view a smaller fraction of the sky. It will comprise a special kind of pinhole camera called a coded aperture mask placed in front of a large solid-state detector. This will let BAT calculate a burst's location to within a few arc-minutes (a fraction of the Moon's apparent diameter and much finer than BATSE can do).



Next, the spacecraft swings to aim the XRT and UVOT in the neighborhood of the burst. The XRT is based on a proven design for Spectrum X, a Russian/European/U.S. mission, set for launch in 2003. It is sensitive to X-rays in the 0.2 to 10 kilo-electron volt (keV) range and has a 24 arc-minute field of view, slightly smaller than the Moon's apparent diameter.

Left: The XRT and UVOT will be coaligned on the Swift spacecraft, while BAT covers a much larger field of view. The entire spacecraft will turn when BAT detects a burst. Credit: NASA/Goddard.

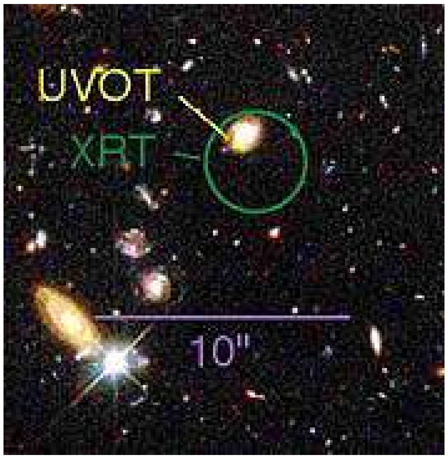
The UVOT, derived from the optical telescope that Europe's X-ray Multi-Mirror Mission satellite (XMM) will carry, has a 30 cm (12 in.) primary mirror, equivalent to a 4-meter (13.2 ft) telescope on the ground, Gehrels said. It will have a 17 arc-minute field of view (slightly more than half the apparent diameter of the Moon) and sensitivity from 170 nm (ultraviolet) down to 650 nm (deep red).

Using the two telescopes, scientists should be able to locate bursts to within 0.3 arc-seconds, and to tell whether the burst has an optical transient that should be the target of follow-up observations by larger observatories in orbit or on Earth.

While waiting for bursts to go off, Swift will map the sky at high x-ray energies. This hasn't been done since the first High Energy Astronomy Observatory (HEAO-1), which orbited during 1977-79. BAT will be 50 times more sensitive that HEAO-1's Hard X-Ray/Low Energy Gamma Ray Experiment, so it will provide more detailed maps that will help observers find new targets for the Chandra X-ray Observatory and XMM.

Web Links
Swift project at NASA/Goddard describes the spacecraft and its mission. HETE-II, the High Energy Transient Explorer project at MIT Super-LOTIS homepage at Clemson University. And, of course, BATSE, the instrument that has taught us so much about bursts.

This mapping mission will require some patience, though, since Swift will automatically chase a burst as soon as one is detected.



Another break from NASA tradition, Gehrels explained, is that Swift's burst data will be made available as soon as they come through since time is of the essence in burst observations. Within 10 seconds, Swift should have a 10 arc-minute determination of a burst's location. In less than three minutes, it will have an X-ray or optical determination to less than an arc-second. And that will allow follow-up observations, in the weeks and months that follow, with large observatories like the Hubble Space Telescope that require much more planning to repoint.

Right: The relative fields of view of Swift's two telescopes are overlaid on a segment of the Hubble deep-field image. Swift will provide locations refined enough for Hubble and other high-power telescopes to study bursts in detail. Credit: NASA/Goddard.

And beyond that? After a lead role, most stars look for a blockbuster role. In this case, it will be the Next Generation Gamma-Ray Burst Observatory.

"We want NASA to begin to form a group within this next year to study the mission requirements" for what would come after Swift, said Dr. Gerald Fishman, principal investigator for BATSE at NASA's Marshall Space Flight Center.

"Swift serves as a pathfinder" for the next-generation instrument, Fishman said. "We won't firm up plans until it makes its observations" since those could change the requirements. The design is so distant for now that the next-generation telescope might comprise several spacecraft operating together, and almost certainly will operate interactively with advanced missions like the Gamma-Ray Large Space telescope (GLAST) planned for launch in 2005.

The next-generation instrument would also be used in concert with major observatories on Earth and in orbit.

"This mission is seen primarily as a NASA facility," Fishman continued, "designed by the entire NASA community and used by the science community. Although NASA would play a lead role, it is expected to have international support."

Fishman said scientists are also looking at a new operational model that would involve the National Science Foundation as a full partner rather than having the observatory operated and funded primarily by and for NASA. NSF operates many of the United States' ground-based observatories.

"Since the science is something of interest to both agencies" - ground-based observatories often seek optical counterparts for bursts - "it should be funded by both agencies," Fishman said.

Since Swift won't start chasing bursts until 2003, the Next Generation Gamma-Ray Burst Observatory won't even be designed until around 2005 for launch in 2010 or later.

Left: Engineers at MIT prepare HETE-II for launch. Credit: MIT

Meanwhile, other instruments are helping keep gamma-ray bursts in the limelight. The High-Energy Transient Explorer (HETE-II; the first failed to reach orbit in 1998) is set for launch on Jan. 23. It has a smaller detector than Swift and will only stare at a section of sky away from the sun, so it will detect only 30 or so bursts a year. But HETE-II also has ultraviolet and X-ray instruments that will provide a refined location to help larger telescopes target bursts for follow-up observations.

Right: A Clemson University student examines the primary mirror for Super-LOTIS. Credit: Clemson University.

Chasing those locations will be Super LOTIS, built from an old 60 cm (24-in) reflector telescope provided by the Lick Observatory. Super LOTIS - the Livermore Optical Transient Imaging System built by Lawrence Livermore National Laboratory - has been in tests since "first light" on Feb. 25, 1999.

In addition to looking at night for optical afterglows of gamma-ray bursts, it is programmed to record burst triggers that happen during the day and then try to locate their afterglows at night. Super LOTIS is scheduled to be relocated from Lawrence Livermore to the Kitt Peak National Observatory near Tucson, Arizona where observing conditions are better.

1999 GRB Symposium series

Oct 29: A Swift Look at the Biggest Explosions in the Universe Spurred by the thousands of gamma-ray bursts recorded over the last three decades, NASA is planning missions dedicated to discovering the causes of what had been an oddity and now has become a primary mystery.

Oct 25: Postmortems in the Sky To say they are ghoulish may be going too far, but like ghouls those studying Gamma Ray Bursts gleefully seek the moldering remains, and never see the living victim. But they are very much interested in both the victim and the cause.

Oct 21: Dodging pitfalls in the hunt for the cause of gamma-ray bursts Scientists discuss how to avoid making mistakes while searching for the solution to a big astrophysical mystery - What causes gamma-ray bursts?

Oct 20: Outbursts Result in Controversy Scientists have different ideas to explain the behavior of Soft Gamma Repeaters (SGRs).

Oct 18: After three decades of study, gamma-ray bursts still mystify Science@NASA caught up with Dr. Gerald Fishman for an interview about bursts and the symposium.

Oct 11: Gamma-ray bursts to take center stage at international meeting More than 200 astronomers will gather to talk about gamma-ray bursts, one of the most mysterious and increasingly watched-for phenomena in the universe.

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For more information, please contact: Dr. John M. Horack , Director of Science Communications	Author: Dave Dooling Curator: Linda Porter NASA Official: M. Frank Rose

Leonids in the Crystal Ball

Most experts agree that 1999 is a likely year for a Leonids meteor storm.

October 27, 1999: Imagine tuning in to the local TV weather report and hearing this from the weatherman:

"Good evening space weather lovers! Last night Earth was hit by a high-pressure solar wind stream. It's expected to persist for 3 or 4 more days producing a 50% chance of mid-latitude aurora. But the big news today is the 1999 Leonid meteor shower. Experts are predicting a big storm on November 18th with up to 100,000 shooting stars per hour. Of course, we could be off by a couple of years. The storm might hit in 2001 instead. Or maybe not at all! Hey, if predicting these things were easy we wouldn't need experts!"

Right: Lorenzo Lovato captured this stunning picture of a -10 magnitude Leonid fireball on November 17, 1998 from Monteromano, Italy. He used Fuji 800 film with a 16 mm f/2.8 lens for an exposure time of 15 minutes. Copyright 1998, Lorenzo Lovato, all rights reserved.

One day, space weather forecasts like this could be commonplace. As our society comes to rely on satellites, cell phones, and other space-age gadgets, forecasting solar storms and meteor showers can be just as important as knowing the chances of rain tomorrow. Three weeks from now we may be treated to a very visible reminder of space weather when the Leonid meteor shower strikes on November 18, 1999.

What's the probability of significant meteoroid precipitation? That's what stargazers and satellite operators everywhere would love to know.

Most experts would agree that predicting the Leonids can be tricky. To understand why it's helpful to know the difference between a "meteor shower" and a "meteor storm." Simply put, meteor showers are small and meteor storms are big. Meteor showers produce a few to a few hundred shooting stars per hour. Meteor storms produce a few thousand to a few hundred thousand meteors per hour. A meteor storm, like a total solar eclipse, ranks as one of Nature's rarest and most beautiful wonders.

A Leonid meteor *shower* happens every year around November 17 when Earth passes close to the orbit of comet Tempel-Tuttle. Usually not much happens. The Earth plows through a diffuse cloud of old comet dust that shares Tempel-Tuttle's orbit, and the debris burns up harmlessly in Earth's atmosphere. A typical Leonid meteor shower consists of a meager 10 to 20 shooting stars per hour.

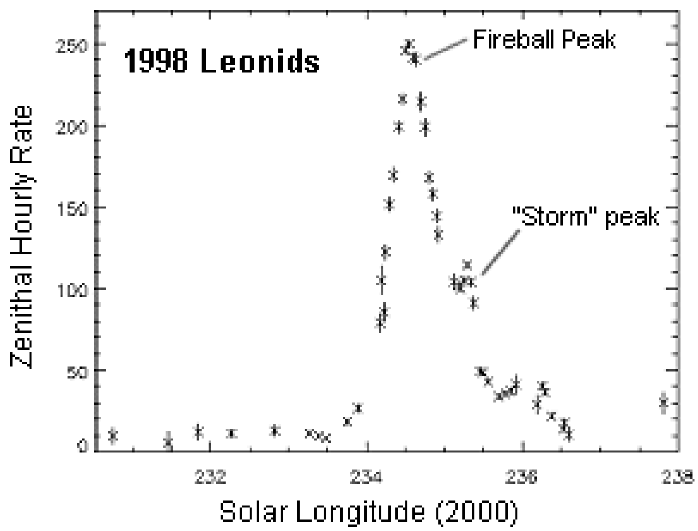
Parents and Educators: Please visit Thursday's Classroom for lesson plans and activities related to this story.

Every 33 years something special happens. Comet Tempel-Tuttle swings through the inner solar system and brings a dense cloud of debris with it. For 3 or 4 years after its passage the Leonids can be very active. In 1966 for instance, over 100,000 meteors per hour were seen from parts of North America.

Curiously, there isn't a full-fledged storm every time Tempel-Tuttle passes by. Sometimes there's simply a stronger-than-average shower. Sometimes nothing happens at all!

Will there be a storm in 1999? (Probably, yes.)

Tempel-Tuttle visited the inner solar system most recently in late 1997 and early 1998. The subsequent Leonids display, in Nov. 1998, was marvelous as observers all over the world were treated to a dazzling display of fireballs (shooting stars with magnitudes brighter than -3). Nevertheless, the 1998 Leonids were a shower, not a storm. The maximum rate of meteors last year was about 250 per hour. Scientists have learned that if Earth crosses the orbit of Tempel-Tuttle *too soon* after the comets passage, then there is no storm, just a strong shower. Apparently that's what happened in 1998. In recent history no Leonid storm has ever occurred less than 300 days after Tempel-Tuttle passed by Earth's orbit. In 1998, Earth followed the comet to the orbit-crossing point by only 257 days [ref].



The period of maximum activity during the 1998 Leonid shower took place about 12 hours before the earth crossed Tempel-Tuttle's orbital plane. The early activity caught many observers by surprise, but it was business as usual for the unpredictable Leonids. Rainer Arlt of the International Meteor Organization noted that while the maximum activity came early, there was a secondary maximum when the Earth passed the comet's orbit (see left). This pattern is similar to that observed in 1965, the year that preceded the great Leonids storm of 1966. In his report, Bulletin 13 of the International Leonid Watch: The 1998 Leonid Meteor Shower, Arlt wrote:

> *[T]he radar, visual, and photographic records of the 1965 Leonids indicate an activity profile which resembles that of the 1998 Leonids. Even the low population index seems comparable. Judging from these phenomenological facts, we may expect 1999 to show a similar shape of activity as in 1966. The actual maximum meteor numbers are hardly predictable.* [ref].

Above: 1998 Leonids activity based on visual records from 217 observers who saw more than 47,000 Leonids in 858 observing hours. The vertical axis is the "zenithal hourly rate" of visual meteors, or the hourly rate of meteors an observer would witness under ideal conditions with the meteors appearing directly overhead. The horizontal axis is the solar longitude of Earth, and may also be regarded as time increasing from left to right. The "Fireball peak" corresponds to the impressive fireball display of Nov. 17, 1998. The smaller "Storm peak" occurred approximately 12 hours later just as Earth was crossing the orbital plane of Tempel-Tuttle. Credit: The International Meteor Organization.

If the 1999 Leonids are anything like the 1966 storm, stargazers are definitely in for a treat. The 1966 event was, predictably, somewhat unexpected. The comet had passed by Earth's orbit in 1965, so astronomers were aware that something might happen. But, judging by the paucity of the 1899 and 1932 showers, it was widely thought that the orbit of the debris stream had been deflected so much by gravitational encounters with other planets (mainly Jupiter) that a close encounter with Earth's orbit was no longer possible. The best predictions suggested a strong shower over Western Europe with 100 or so meteors per hour.

Instead, there was an stunning display of shooting stars over western North America. This recollection by James Young at JPL's Table Mountain Observatory in California gives a sense of what the storm was like:

> *"This very noteworthy [1966] meteor shower was nearly missed altogether... There were 2-5 meteors seen every second as we scrambled to set up the only two cameras we had, as no real preparations had been made for any observations or photography. The shower was expected to occur over the European continent.*
>
> *The shower peaked around 4 a.m., with some 50 meteors falling per second. We all felt like we needed to put on 'hard hats'! The sky was absolutely full of meteors...a sight never imagined ... and never seen since! To further understand the sheer intensity of this event, we blinked our eyes open for the same time we normally blink them closed, and saw the entire sky full of streaks ... everywhere!"*

The 1966 return of the Leonids was one of the greatest displays in history, with a maximum rate of 2400 meteors per minute or 144,000 per hour.

Joe Rao, a Leonids expert who lectures at New York's Hayden Planetarium, also advocates 1999 as possibly the best year for a storm during this 33 year cycle. Writing for Sky &Telescope he says:

> *Based on what happened last November, I will venture a prediction. If a meteor storm is to take place at all, 1999 would appear to be the most likely year for it to happen. But even if this year's Leonids are richer in number, observers should not expect the same high proportion of fireballs that were seen in 1998. Instead, a more even mix of bright and faint meteors is likely.* [ref]

Rao bases his argument on historical precedent and the Earth-comet geometry. During the seven most recent Leonid storms when Earth crossed Tempel-Tuttle's orbit soon after the comet, the average distance between the comet and Earth was 0.0068 astronomical unit. The average number of days between the comet's passage and the Earth's arrival at the plane of the comet's orbit was 602.8 days. With the 1999 values of 0.0080 AU and 622.5 days, Rao says we ought to be in a prime position to see significant, if not storm-level, activity.

Rao is also a meteorologist for News 12 Westchester, which seems a suitable occupation for predicting meteor showers.

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In 1999, the Earth will pass nearly three times as far from the comet's orbital path as it did in 1966 and more than six times farther than it did during the great storm of 1833. If the peak of the Leonids arrives exactly when the Earth passes through the comet's orbital plane, Donald Yeomans of JPL gives 01:48 UT on November 18, 1999 as the most likely time for the 1999 maximum [ref]. That would make Europe and West Africa the best places to watch the show. However, Leonid meteor showers frequently arrive much earlier or later than predicted, so any place on the globe could be favored.

If the peak of the Leonids occurs over Europe or the Atlantic Ocean, then observers in the USA could be in for an unusual treat. The Leonid radiant would just be rising over North America at the time. In the eastern US sky watchers would see a large number of earth-grazing meteors skimming horizontally through the upper atmosphere. "Earth grazers" are typically long and dramatic, streaking far across the sky.

To look or not to look, that is the question

> *All sorts of conjectures were made by all sorts of people ... We may learn of this that, when*

men are in a high state of excitement, their testimony must be taken with many grains of allowance.

From a first-hand account of the 1833 Leonid Meteor Shower. by Elder Samuel Rogers

Most experts agree that 1999 is the most likely year for a Leonids meteor storm during the current 33 year cycle. However, if 1999 turns out to be a disappointment, don't despair! There are other studies that suggest 2000, 2001 or even 2002 could be better years. The Leonids are simply hard to forecast.

If 1999 is the year, when should you look? Most experts predict that the Leonids peak will occur between 0100 and 0400 Universal Time on November 18th. However, it is important to remember that such predictions are always uncertain. The 1998 Leonid fireball display occurred nearly 16 hours before the predicted maximum! No matter where on Earth you live, the morning of November 18 will probably be the best time to look for Leonids in 1999. This is true even if morning where you live occurs much earlier or later than 0100-0400 UT.

Conventional wisdom says that meteor observing is always best between midnight and dawn local time on the date of the shower (November 18 in this case). For a shower or storm like the Leonids that might be relatively brief, it is best to start watching no later than midnight. In fact, when the author of this story went outside last year at midnight to view the 1998 Leonids, the shower was already well underway! With this in mind you may decide it's a good idea to begin observing even earlier, say, 10 p.m. on November 17.

In the coming weeks Science@NASA will post more stories about the Leonids with observing tips for meteor watching with the naked eye, video cameras and other types of recording devices. One thing seems sure, no matter where you live: The Leonids are coming and, on Nov 18, 1999 the place to be is outside, looking up!

Web Links

Leonids Live! -site of the live webcast of the 1998 Leonids

Awaiting the Storm - by Joe Rao in Sky&Telescope

Bulletin 13 of the International Leonid Watch: The 1998 Leonid Meteor Shower - by Rainer Arlt of the International Meteor Organization

The November Leonids: Will They Roar? - Leonids predictions from Donald Yeomans of JPL

Asher, DJ, Bailey, ME and Emel'yanenko, VV "Resonant meteoroids from Comet Tempel-Tuttle in 1333: the cause of the unexpected Leonid outburst in 1998," Mon. Not. R. Astron. Soc. 304, L53-L56 (1999)

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Tuning in to April Meteors -- Apr. 27, 1999.Amateur astronomers capture radio echoes from fiery meteors in April 99

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A Wild Ride to the Stratosphere -- Apr. 14, 1999. A weather balloon hits the stratosphere in search of meteoroids

Meteor Balloon set for Launch -- Apr. 8, 1999. This weekend scientists will launch a weather balloon designed to capture meteoroids in the stratosphere.

Leonid Sample Return Update -- Apr. 1, 1999. Scientists will describe initial results from a program to catch meteoroids in flight at the NASA/Ames Leonids Workshop April 12-15, 1999.

The Ghost of Fireballs Past -- Dec. 22, 1998. RADAR echoes from Leonid and Geminid meteors.

Bunches & Bunches of Geminids -- Dec. 15, 1998. The Geminids continued to intensify in 1998

The 1998 Leonids: A bust or a blast? -- Nov. 27, 1998. New images of Leonid fireballs and their smoky remnants.

Leonids Sample Return payload recovered! -- Nov. 23, 1998. Scientists are scanning the "comet catcher" for signs of Leonid meteoroids.

Early birds catch the Leonids -- Nov. 19, 1998. The peak of the Leonid meteor shower happened more than 14 hours earlier than experts had predicted.

A high-altitude look at the Leonids -- Nov. 18, 1998. NASA science balloon catches video of 8 fireballs.

The Leonid Sample Return Mission -- Nov. 16, 1998. NASA scientists hope to capture a Leonid meteoroid and return it to Earth.

Great Expectations: the 1998 Leonid meteor shower -- Nov. 10, 1998. The basics of what the Leonids are and what might happen on November 17.

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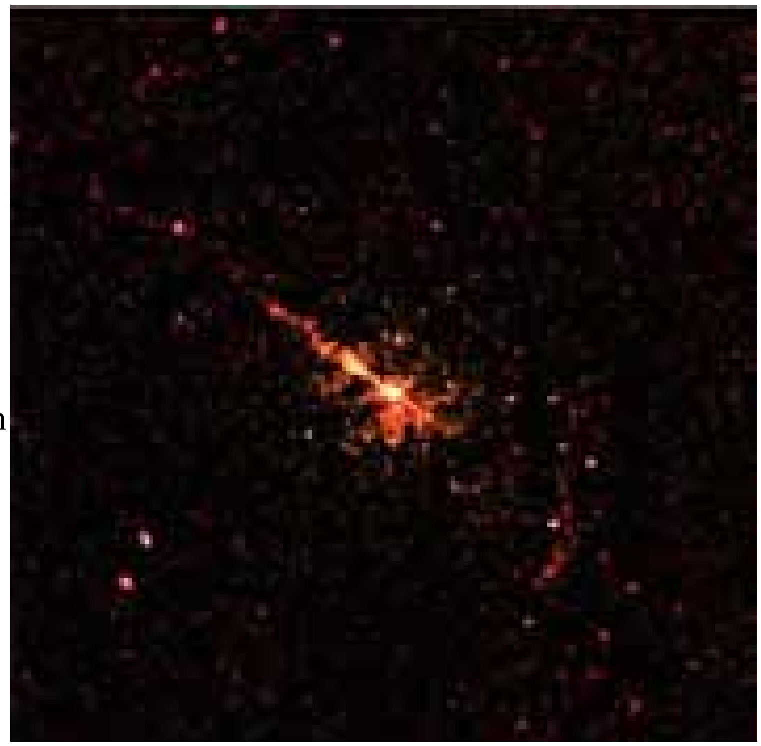
Chandra Spies Structure of Huge X-Ray Jets

Extended X-Ray Jet in Nearby Galaxy Reveals Energy Source

BASED ON A NASA/MSFC PRESS RELEASE

October 26, 1999: NASA's Chandra X-ray Observatory has made an extraordinary image of Centaurus A, a nearby galaxy noted for its explosive activity. The image shows X-ray jets erupting from the center of the galaxy over a distance of 25,000 light years. Also detected are a group of X-ray sources clustered around the nucleus, which is believed to harbor a supermassive black hole. The X-ray jets and the cluster of sources may be a byproduct of a titanic collision between galaxies several hundred million years ago.



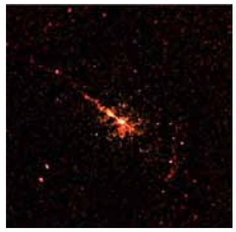
Right: Centaurus A as viewed from the Chandra X-Ray Observatory shows two x-ray jets extending from a galactic center thought to be home to a huge black hole at the center. The image links to a 540x533-pixel, 138 KB JPG. Or, click here for a 2250x2221-pixel, 3.6MB TIFF. Image credit: NASA and Chandra Science Center

"This image is great," said Dr. Ethan Schreier of the Space Telescope Science Institute, "For twenty years we have been trying to understand what produced the X rays seen in the Centaurus A jet. Now we at last know that the X-ray emission is produced by extremely high energy electrons spiraling around a magnetic field." Schreier explained that the length and shape of the X-ray jet pinned down the source of the radiation. The entire length of the X-ray jet is comparable to the diameter of the Milky Way Galaxy.

Other features of the image excite scientists. "Besides the jets, one of the first things I noticed about the image was the new population of sources in the center of the galaxy," said Dr. Christine Jones from the Harvard-Smithsonian Center for Astrophysics. "They are grouped in a sphere around the nucleus, which must be telling us something very fundamental about how the galaxy, and the supermassive black hole in the center, were formed."

infrared
Photo:*2 MASS*

optical
Photo:*AURA/NOAO/NSF*



x-ray
Photo:*NASA/CXC/SAO*

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Above: Centaurus A as viewed in four different spectra. The brilliant jet so visible in the x-ray is perpendicular to the apparent plane of the galaxy in visible or infrared. See the Chandra X-Ray Observatory Center's *What Do These Images Tell Us* page for more information.

Astronomers have accumulated evidence with optical and infrared telescopes that Centaurus A collided with a small spiral galaxy several hundred million years ago. This collision is believed to have triggered a burst of star formation and supplied gas to fuel the activity of the central black hole.

According to Dr. Giuseppina Fabbiano, of Harvard-Smithsonian, "The Chandra image is like having a whole new laboratory to work in. Now we can see the main jet, the counter jet, and the extension of the jets beyond the galaxy. It is gorgeous in the detail it reveals," she said.

Dr. Allyn Tennnant of NASA's Marshall Space Flight Center agreed. "It's incredible, being able to see all that structure in the jet," he said. "We have one fine X-ray telescope."

Indeed at a distance of eleven million light years from Earth, Centaurus A has long been a favorite target of astronomers because it is the nearest example of a class of galaxies called active galaxies. Active galaxies are noted for their explosive activity, which is presumed to be due to a supermassive black hole in their center. The energy output due to the huge central black hole can in many cases affect the appearance of the entire galaxy.

The Chandra X-ray image of Centaurus A, made with the High Resolution Camera, shows a bright source in the nucleus of the galaxy at the location of the suspected supermassive black hole. The bright jet extending out from the nucleus to the upper left is due to explosive activity around the black hole that ejects matter at high speeds from the vicinity of the black hole. A "counter jet" extending to the lower right can also be seen. This jet is probably pointing away from us, which accounts for its faint appearance.

One of the most intriguing features of supermassive black holes is that they do not suck up all the matter that falls within their sphere of influence. Some of the matter falls inexorably toward the black hole, and some explodes away from the black hole in high-energy jets that move at near the speed of light. The presence of bright X-ray jets in the Chandra image means that electric fields are continually accelerating electrons to extremely high energies over enormous distances. Exactly how this happens is a major puzzle that Chandra may help to solve.

Dr. Stephen Murray of the Harvard-Smithsonian Center for Astrophysics is the principal investigator for the High Resolution Camera. NASA's Marshall Space Flight Center in Huntsville, AL, manages the Chandra program. TRW, Inc., Redondo Beach, CA, is the prime contractor for the spacecraft. The Smithsonian's Chandra X-ray Center controls science and flight operations from Cambridge, MA.

Web Links

Xrayastronomy.com, science news from the Chandra X-Ray Observatory
Chandra X-ray Observatory Center home page, with links to education, news, and technical pages.
Chandra news from Marshall Space Flight Center
Chandra Project Science is managed at NASA/Marshall, has links to individual instruments and the prime contractor.
X-ray astrophysics branch at NASA/Marshall conducts a broad range of research and technology work, as well as supporting the Chandra X-ray Observatory.

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Postmortems in the Sky

Gamma Ray Bursts are part of the evidence, but what is the cause?

October 25, 1999: While it's not quite Halloween, a radio astronomer struck that chord when he described astrophysicists' fascination with gamma-ray bursts.

"We're interested in dead and dying things," said Dr. Dale Frail of the National Radio Astronomy Observatory in Socorro, N.M. "Our highest ambition is to know who that dying thing is."

Frail spoke during the third day of the week-long Fifth biennial Huntsville Gamma Ray Burst Symposium. Gamma-ray bursts are mysterious flashes of high-energy radiation that come from the edge of the observable universe. Since their discovery by gamma-ray detectors designed to watch for nuclear weapons tests in space, scientists have tried to find counterparts in other parts of the spectrum so they might figure out what causes the bursts.

Astrophysicists engage in "forensic science," Frail said, when they study gamma-ray bursts because they look at the remains without having ever seen the victim alive. Frail works in radio astronomy, the end of the spectrum that comes into play when the "corpse is cold and still," volunteered one member of the audience. By comparison, scientists using instruments like the Burst and Transient Source Experiment (BATSE) are "interested in hearing the death rattle," Frail joked.

The death rattles as detected in various parts of the electromagnetic spectrum are all anyone can examine so far in the bid to uncover what causes such horrible deaths out at the edges of the known universe.

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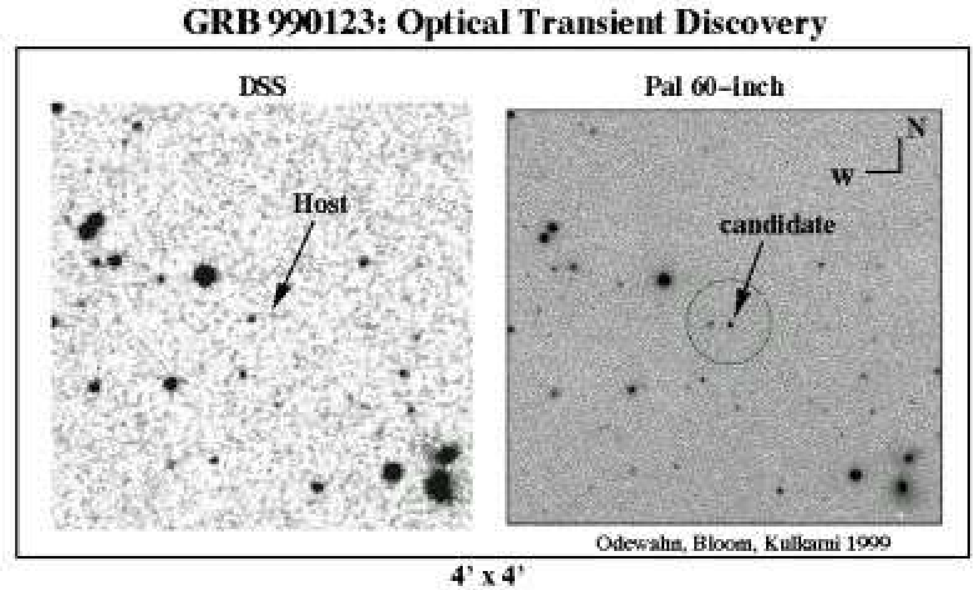
The death rattle and last gasp are mostly what scientists have to go on since it's impossible to bring major observatories to bear on a burst as it occurs, and far too much to hope that a telescope will be observing something when a burst happens to go off nearby. While BATSE and a few other instruments can record the gamma-ray flash of a burst, the rest of the astronomy community have to work with the afterglow - if a counterpart is found in other parts of the spectrum - which can last hours or a year.



Left: These are the discovery images of the optical afterglow emission from GRB 990123. The left panel shows the star field as it appeared prior to the explosive gamma-ray burst. A faint galaxy, indicated with an arrow, was originally proposed to contain the gamma-ray burst source. Now, however, the galaxy is thought to be in the foreground. The right panel shows the optical emission, observed about 4 hours after the gamma-ray burst on January 23, dominating the light from the faint galaxy. Credit: Dr. Stephen Odewahn/Caltech-NRAO-CARA GRB Collaboration.

Frail believes that radio emissions from the afterglow provide unique information on the burst environment and the burst progenitor itself. Using the radio telescopes in Socorro and other institutions, he has looked for radio counterparts in bursts where optical or X-ray counterparts were found. In some cases, they were seen in radio and X-rays, but not visible light.

"I believe that we are seeing a class of events that are optically dark (because) they are obscured by dust in the areas where the gamma-ray bursts exploded," he said. The observations have provided a powerful test of models of fireballs that expand outward from bursts.

Afterglows are also seen in visible and near-visible wavelengths and continue to be among the most valued because they help scientists in trying to locate the hosts of bursts. A total of 14 have been observed with the Hubble Space Telescope and point very strongly to a home for bursts.

"In every case, the gamma-ray burst is right on top of the stellar field," said Dr. Andrew Fruchter of the Space Telescope Science Institute in Baltimore. "It is not in the open where you find gaps" between galaxies near the edge of the observable universe.

Further, many of the bursts are associated with blue galaxies, which are observed to have high rates of star birth.

"All of these things are consistent with star formation," Fruchter said.

In many cases, the optical afterglow components are barely visible to Hubble, despite its incredible light gathering power. GRB 970228 (the numbers are the date of the burst) is the landmark sighting because it was the first optical component to be captured in visible light. When Hubble was able to look at it some weeks later, scientists saw "a small smudge in the sky," a dwarf galaxy with the fading embers of the burst.

Web Links
Gamma-ray bursts to take center stage at international meeting Oct. 11. More than 200 astronomers will gather to talk about gamma-ray bursts, one of the most mysterious and increasingly watched-for phenomena in the universe. The 5th Huntsville Gamma Ray Burst Symposium, to be held Oct 18-22 in Huntsville, Alabama, will have a wealth of new observations for discussions of bursts and how to study them. Burst and Transient Source Experiment web site includes links to work with BATSE and to the 5th Huntsville Gamma Ray Burst Symposium. Scientists catch another gamma-ray burster in visible light - May 18, 1999. Several telescopes observe optical counterpart Cosmic gamma-ray bursts NEWS & RESEARCH GOTCHA! The Big One That Didn't Get Away - Jan. 27, 1999. For the first time, images of visible light from a gamma ray explosion is captured by a robotic telescope. Gamma-ray Bursters cross the 'Line of Death' - Oct. 13, 1998. A study of gamma-ray burst spectra shows one more thing that these mysterious, cosmological gamma-ray bursts are not. Blast from the past: the latest clue in solving the gamma-ray burst mystery (May 6, 1998). Gamma-ray burst identification earns top prize (Jan. 12, 1998) Twinkle, twinkle, massive fireball - reports from the 4th Huntsville Gamma-ray Burst Symposium (Sept. 17, 1997) Discovery may be "smoking gun" in gamma-ray mystery (March 31, 1997).

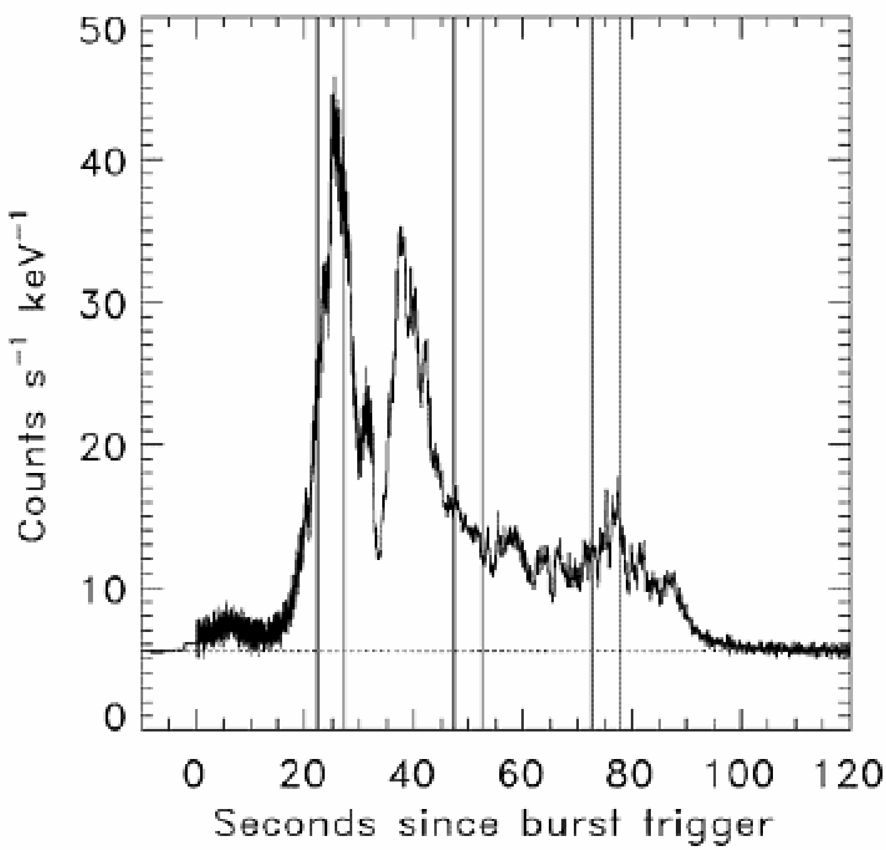
In several cases, Hubble's resolution and its ability to distinguish colors have allowed scientists to pick out burst afterglows and barely observable host galaxies. Fruchter described one irregular galaxy as "having the morphology of a train wreck."

Back in the radio end of the spectrum, Dr. Shri Kulkarni of the California Institute of Technology outlined evidence from radio astronomy and other fields that support two leading theories of what causes bursts. One is that two neutron stars coalesce to form a black hole, the other is that a massive supernova or "collapsar" explodes and also forms a black hole.

"It's like when people discovered supernovae," Kulkarni said. "People didn't know what they were, but eventually they figured it out." Supernovae now are known to be massive stars that blow themselves out with a great fury after a short but brilliant life.

Kulkarni said that there is "strong indirect evidence connecting [bursts] to massive stars in dusty hosts or with dust along the line of sight."

Whatever the cause, it is followed by an intense blast wave as the materials move outward from the source through interstellar space. But even then scientists are still puzzling over exactly what they are seeing. Dr. Titus Galama, who recently joined CalTech after a long stay at the University of Amsterdam, described the different spectra recorded for the famous burst of Jan. 23, 1999 (GRB 990123). The Robotic Optical Transient Search Experiment (ROTSE) caught this burst in optical wavelengths within seconds of its detection by BATSE.



The burst was brilliant enough that had it been in the nearby M31 galaxy in Andromeda, it would have appeared as bright as the full moon. But despite having ROTSE and BATSE data that overlap in time, "there is no simple relationship between ROTSE's observations and BATSE." Galama said. He showed a graph with data from both instruments. The ends of data lines from BATSE and ROTSE did not point towards each other to indicate that one was a continuation of the other.

Left: This figure shows the how the brightness in gamma rays, as observed with BATSE, varied during GRB 990123. The three intervals marked by vertical lines indicate the times during which ROTSE obtained its first three visible images. Credit: Dr. Michael Briggs, NASA/Marshall.

"The prompt optical emission is not a simple extrapolation of the BATSE data to lower wavelengths," Galama said, "so we conclude that ROTSE and BATSE are seeing different components."

He suggested that BATSE sees gamma rays produced by internal shock waves as the exploding gas interacts with itself. The optical or visible part is caused by the external shock wave blazing forward through space and ramming into whatever dust and gas are there. Since that material can vary: some regions like the Coal Sack Nebula are so dense that the absorb light from stars and galaxies behind them, others are empty "superbubbles" swept clean by previous star explosions.

Finally, a late afterglow appears in gamma rays as the external shock wave causes reverse shocks within the expanding explosion. This appears in gamma rays as a smooth tail whose high spot early in the blast is masked by the blast itself.

But again in the spirit of Halloween, gamma-ray bursts can wear different masks, and not every one follows this basic model.

"To a first order," Galama concluded, "we have excellent agreement with the fireball model. But we have some oddities to investigate."

1999 GRB Symposium series

Oct 25: Postmortems in the Sky To say they are ghoulish may be going too far, but like ghouls those studying Gamma Ray Bursts gleefully seek the moldering remains, and never see the living victim. But they are very much interested in both the victim and the cause.

Oct 21: Dodging pitfalls in the hunt for the cause of gamma-ray bursts Scientists discuss how to avoid making mistakes while searching for the solution to a big astrophysical mystery - What causes gamma-ray bursts?

Oct 20: Outbursts Result in Controversy Scientists have different ideas to explain the behavior of Soft Gamma Repeaters (SGRs).

Oct 18: After three decades of study, gamma-ray bursts still mystify Science@NASA caught up with Dr. Gerald Fishman for an interview about bursts and the symposium.

Oct 11: Gamma-ray bursts to take center stage at international meeting More than 200 astronomers will gather to talk about gamma-ray bursts, one of the most mysterious and increasingly watched-for phenomena in the universe.

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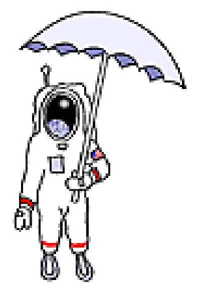
☑		Solar storms, sunspots, solar wind, auroras find out what the weather is in space. Occasional messages predicting possible aurora conditions and other things going on in the solar system. Most Science@NASA subscribers also get this one.

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Curator: Bryan Walls
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Now Updated - I haven't gotten to all the old link addy's yet but I've gotten quite a few checked out and corrected. Plus some new links.

Lightning Strike Survivor's Resource Page

Welcome to The Lightning Strike Survivor's Resource Page.

My name is Christine Fram. I am a survivor of a lightning strike. On August 6,1997 I was struck by lightning while on the job. I live in Vancouver, British Columbia, Canada.

In Canada, every year lightning kills about seven people and seriously injures 60 to 70 others.

I created this page to provide a way to contact other survivors, and for education, to make available accurate information and links to resources that can help us educate ourselves, our doctors, our famillies and our friends.

ESSENTIAL LIGHTNING LINKS

UIC - Lightning Injury Research Program
Canadian Lightning Information
Canadian Lightning Strike Hot Spots
Lightning Strike and Electrical Shock Survivors International
Lightning and Shock News Forum
MGH Chat Rooms. They have a chat room for Lightning Survivors
Direct Link to the Chat Room

My goal is to make this an effective page of Lightning Survivor Resources and to provide an on-line email based support list, where survivors and anyone whose life has been altered by a lightning strike can share, inform, help and support one another. Do you know: 500-600 people a year are struck by lightning in North America? 70% of those people survive.

THE LIGHTNING STRIKE SURVIVOR'S ON-LINE EMAIL SUPPORT LIST

The Lightning Strike Survivor List (LSSL) is an on-line email support group whose members have been affected by Lightning. This includes: survivors, survivors families, caregivers, doctors, People involved in safety issues, and many more. People who want to help and people who need/want to share with others who understand because they've been there.

Do you need a way to communicate with people who know exactly what you're going through and want to offer their emotional support? Are you someone who wants to share your experience, strength and hope?

Some survivors have said it has helped end feelings of loneliness and isolation, others have said it has helped them create hope and goodness from sadness and injury.

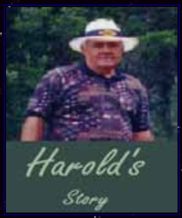
My mission for the LSSL is to encourage survivors to help each other by sharing the resources (health, medical, insurance, LS&ESSI etc.) they have found during their journey towards recovery and by sharing their own experiences and feelings.

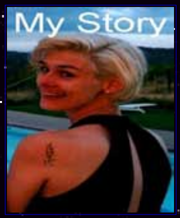
I invite you to join the Lightning Strike Survivor's List.

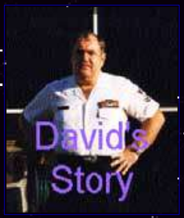
It's easy to do. Just enter your email address in the form below and click join. The subscription will have to be approved by a list manager (either myself or Becky). When we receive the subscription request, you will be sent a brief email asking if you understand what the list is. This is just to prevent subscriptions from people who mistakenly subscribe. It is not meant in any way to qualify or disqualify anyone from joining.

Click to subscribe to lightningstrike

My Inbox always has space for you! *Write Christine a letter*







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Facts About Lightning and The People it Injures	Common Symptoms and Injuries that Survivor's May Experience
When Lightning Strikes People - NASA Science article	

LIGHTNING STRIKE and
ELECTRIC SHOCK SURVIVORS, INT., INC.
PHOTO GALLERY
April 1999, Pigeon Forge, TN

LIGHTNING STRIKE and
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PHOTO GALLERY
10th Annual Conference
April 2000, Pigeon Forge, TN

OTHER SURVIVORS PAGES

Spot's (Mitakuye Oyasin) Lightning Page
Mad Max Dearing
Sabrina's Children's Lightning Safety Page
Martin County SkyWarn - David Smith
Lightning Strike Survivor Mike - Photographs of Lightning

Canadian Geographic featured my story in it's July/Aug 2000 issue.

You can read it on-line.

click on this link.

The Weather Series "STORM WARNING" 2000/01 Season features my story in Episode 405 -Forces of Nature. It airs on The Discovery Channel. So if you happen to see it, it's me. It re-runs quite often and many people ask if I'm the person in the show, so I thought I'd post the info here. I am also featured in TLC's (The Learning Channel)'s Science at the Edge Series. Episode 3: Breaking Nature's Rules (2002)

Future Additions to Come to this Page:

More survivors stories, The Short and Long Term effects of being struck by lightning, and ODDs 'n' Ends.

Dedication Page:
To All Who Have
Helped Along the Way

Please take a moment to read and sign my Guestbook. I'd really like to know how you found this page, what you

think
about it, and/or any other comments you may have. I do my best to contact those who sign it but please remember that
I am still recovering from my injuries, so I can't always reply immediately. I will get back to you as quickly as I am able.

Read My Guestbook Sign My Guestbook dreambook 1.5

Sites of Personal Interest:

[Training in Power - A Spiritual Journey of Service... Meditation and Spiritual Training.]

[Environment Canada - Weather Office - Lightning as it happens]

To everyone everywhere, whose paths have crossed with mine: THANK YOU! THANK YOU!
Without any of you there would be no me.
My life has been enriched and blessed by all of you.

This Lightning Strike site is owned by:
Christine Fram

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Created November 22,1998.
Last updated on August 1, 2004.
Building Dreams ONE DAY AT A TIME.

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We teach.

We consult.

We research.

National Lightning Safety Institute (NLSI) is a non-profit, non-product advocacy of lightning safety for both people and structures:

- *Personal Lightning Safety* means anticipating a high-risk situation and moving to a low-risk location.
- *Structural Lightning Safety* means using various exterior and interior defensive systems in a detailed site-specific process.

NLSI provides objective assistance on many kinds of lightning problems. Learn more by:

- Reviewing our company background
- Surveying our current business services

In addition, our website provides a wealth of factual details about lightning issues, some written by NLSI and some by others. For example, read a sample NLSI paper providing an overview of lightning safety methodology for dangerous environments. Check out our informative sections on:

- Lightning Incidents - Reports of damage done by various lightning strikes
- Personal Lightning Safety - Tips for ensuring personal safety around lightning
- Structural Lightning Safety - Guidelines for lightning hazard mitigation for buildings
- Reference Information - Several reference publications and maps about lightning

NEW Order NLSI's illustrated book on Lightning Protection for Engineers.

NEW Order new and updated International Codes and Standards on Lightning Safety.

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- "NSSL Briefings"
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- SMART-Radar Project
- Special Needs Weather Radio
- Severe Thunderstorm Climatology
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National Severe Storms Laboratory

The National Severe Storms Laboratory is one of NOAA's internationally known research laboratories, leading the way in investigations of all aspects of severe weather. Headquartered in Norman OK, the people of NSSL, in partnership with the National Weather Service, are dedicated to improving severe weather warnings and forecasts in order to save lives and reduce property damage.

With research efforts in:

- Radar
- Satellite
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- Tornadoes
- Thunderstorms
- Damaging Winds
- Lightning
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© C. Hane
Shelf cloud and outflow over an Oklahoma lake. Strong outflow winds over large lakes pose danger to small watercraft.

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Contact Us: http://www.nssl.noaa.gov/contact.shtml

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More lightning news from inside hurricanes and tornadoes

News shorts from the Atmospheric Electricity Conference

June 16, 1999

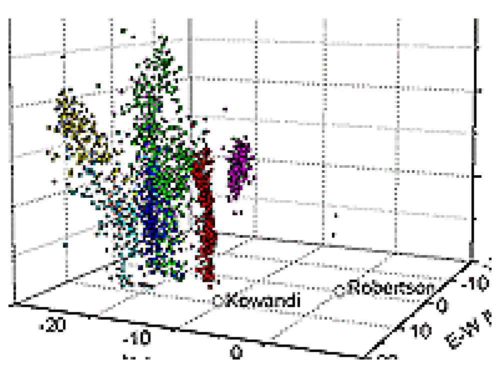
One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

Interference makes for 3D images

Several research teams are developing instruments that allow them to make three-dimensional maps of lightning structure within a storm. One method is to use multiple receivers to measure differences in the arrival times of the radio impulses. Zen Kawasaki of Osaka University in Japan has developed a method that uses differences in the phases of the radio waves as they arrive.

Kawasaki employs two wide-band interferometers. These are radio receivers with four antennas and electronics arranged so the arriving radio waves interfere with each other. This allows the receiver to calculate the direction of the radio pulse coming from a lightning stroke. With two stations set up about 23 km (13.8 mi) from each other, a researcher can determine the origin of a radio pulse.

The two methods are complementary. Paul Khreibel at New Mexico Institute of Mining Technology said his time-of-arrival system is better for three-dimensional and total activity studies, while interferometers like Kawasaki's are better for studying electrification channels within storms.



Kawasaki explained that the interferometers allowed his team to reconstruct the lightning leader's progression as it moved through the cloud before releasing a negatively charged cloud-to-ground flash. He found that the first leader moved at about 100 km/s (about 223,000 mph), but subsequent leaders blasted through at 10,000 km/s (more than 2 million mph).

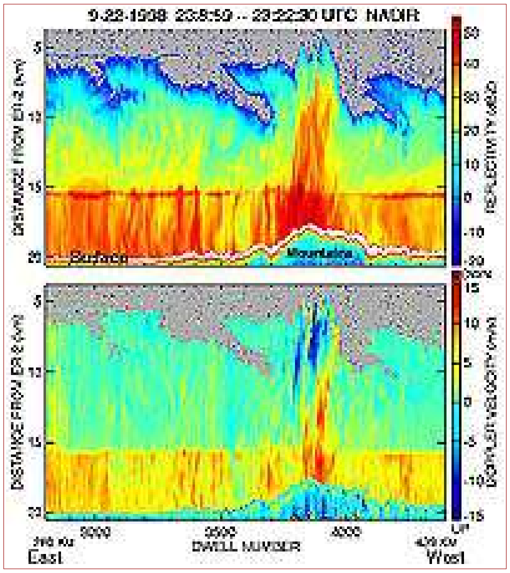
Left: A 3D plot of lightning during a storm, Nov. 20, 1996, over northwest Australia. Links to 512x384-pixel, 26KB GIF. Credit: Osaka University.

"We can clearly get three-dimensional images of the lightning leader," Kawasaki said.

Kawasaki and his researchers tested the system in two field campaigns during the monsoon season in late summer 1996, 1997, and 1998 off Darwin, Australia.

Kawasaki said his team is working on a more sensitive narrow-band interferometer, too. The current narrow-band system has a sensitivity of 1 microsecond (1 million per second). The narrow-band model being developed will take even faster samples, once every 10 nanoseconds (100 million per second).

"With the narrow-band interferometer, we can see positively charged cloud-to-ground flashes," Kawasaki said. "But, they are the negative leader activity."



Hurricane lightning is muted

A hurricane research campaign in 1998 showed that hurricanes typically don't produce much lightning, but sometimes they can.

"What we want to know is why," said Monte Bateman of the Universities Space Research Association. "Some longtime hurricane pilots have reported that when a hurricane does produce lightning, intensification often follows."

Left: Doppler radar on the ER-2 showed an intense updraft as hurricane Georges moved over the island of Hispaniola. Credit: NASA. Links to 126KB jpeg image.

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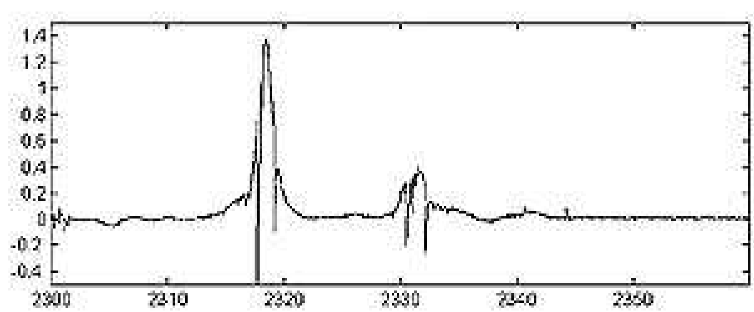
The third Convection and Moisture Experiment (CAMEX 3) in August and September 1998 focused a number of ground, airborne, and satellite instruments on hurricane activities in the western Atlantic Ocean, the Gulf of Mexico and on thunderstorms over Florida. One of the tools used in the campaign was the high-altitude ER-2 reconnaissance aircraft, equipped with eight lightning detectors among other instruments.

The ER-2 recorded only a few lightning flashes as it flew over the eye of hurricane Bonnie on Aug. 26.

Hurricane Georges was a different matter when it waded ashore and battered the island of Hispaniola on Sept. 22. Georges showed "nearly continuous lightning, in and around the eye," Bateman said. In addition, the ER-2 pilot reported seeing about one blue jet every minute for 30 minutes when he was flying over the hurricane. Blue jets are fascinating electrical events that rise from the cloud tops into the upper atmosphere. Their cause is not yet known.



Right: The lightning sensor instruments on the ER-2 showed only modest lightning activity as the aircraft made two passes near the eye of hurricane Georges. Still, this was much more active than what was seen in hurricane Bonnie over the ocean. Credit: NASA

Bateman said that the increased lightning around Georges' eye probably was due to air forced upward - called orographic forcing - when the hurricane hit the mountains. He added that the pilot reported the eye of the hurricane was stacked like a wedding cake over the mountain, rather than being the depressed structure normally seen over the oceans.

As impressive as the difference was, it is muted compared to a normal Florida thunderstorm. Bateman also showed a graph of an Aug. 15 storm that the ER-2 studied. Georges' lightning activity was about 10 times less than the lightning activity in a typical thunderstorm.

Getting up close and almost too personal with a tornado

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Putting instruments in a tornado's path is far more exciting than what movie viewers saw depicted in the hit movie "Twister."

"We were only a few minutes ahead of it," explained Steve Hunyady, an instrumentation engineer at New Mexico Institute of Mining Technology, as he described dropping eight "turtles" outside Allison, Texas, as an F4 tornado approached on June 8, 1995.

The turtles are less attractive than the gold ornaments the actors released into a tornado in the movie. That level of miniaturization is a few years away. But Hunyady said that the turtles were able to provide valuable data about the electric fields around a tornado. Scientists would like to know what happens inside, since observers have reported some lightning and frequent electrical glows inside the vortex.

Each turtle weighs 60 pounds and can be held in place with spikes and lead weights, although when the Allison F4 was bearing down - "We were only a few minutes ahead of it" - the New Mexico Tech team just placed them on the roadside and hurried on to the next position.

"We built them strong so they could be lofted," which wind tunnel tests predicted would happen, but "we've never seen one move yet."

Each turtle contains an electric field meter, a pressure sensor in a small snorkel, a thermometer, and a clock, plus a small computer to store eight hours worth of data.

Fortune was with the researchers that day and the F4 moved almost exactly between two of the turtles. To the researchers surprise, they saw the electric field dipped, and no lightning as recorded.

Hunyady said that lack of electrical activity may be due to lofted debris reducing the electric field, or possibly to increased conductivity inside the tornado itself.

Web Links
Human Voltage (June 18, 1999) Scientists discuss biology, safety, and statistics of lightning strikes. News shorts from Atmospheric Electricity Conference (June 16, 1999) Poster papers on hurricanes and tornadoes summarized. Soaking in atmospheric electricity (June 15, 1999) 'Fair weather' measurements important to understanding thunderstorms. Lightning position in storm may circle strongest updrafts (June 11, 1999) New finding could help in predicting hail, tornadoes Lightning follows the Sun (June 10, 1999) Space imaging team discovers unexpected preferences Spirits of another sort (June 10, 1999) Thunderstorms generate elusive and mysterious sprites. Getting a solid view of lightning (June 9, 1999): New Mexico team develops system to depict lightning in three dimensions. Learning how to diagnose bad flying weather (June 8, 1999): Scientists discuss what they know about lightning's effects on spacecraft and aircraft. Three bolts from the blue (June 8, 1999): Fundamental questions about atmospheric electricity posed at conference this week. Lightning Leaders Converge in Alabama (May 24, 1999): Preview of the 11th International Conference on Atmospheric Electricity. What Comes Out of the Top of a Thunderstorm? (May 26, 1999): Gamma-rays (sometimes). **Lightning research** at NASA/Marshall and the Global Hydrology and Climate Center.

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Soaking in atmospheric electricity

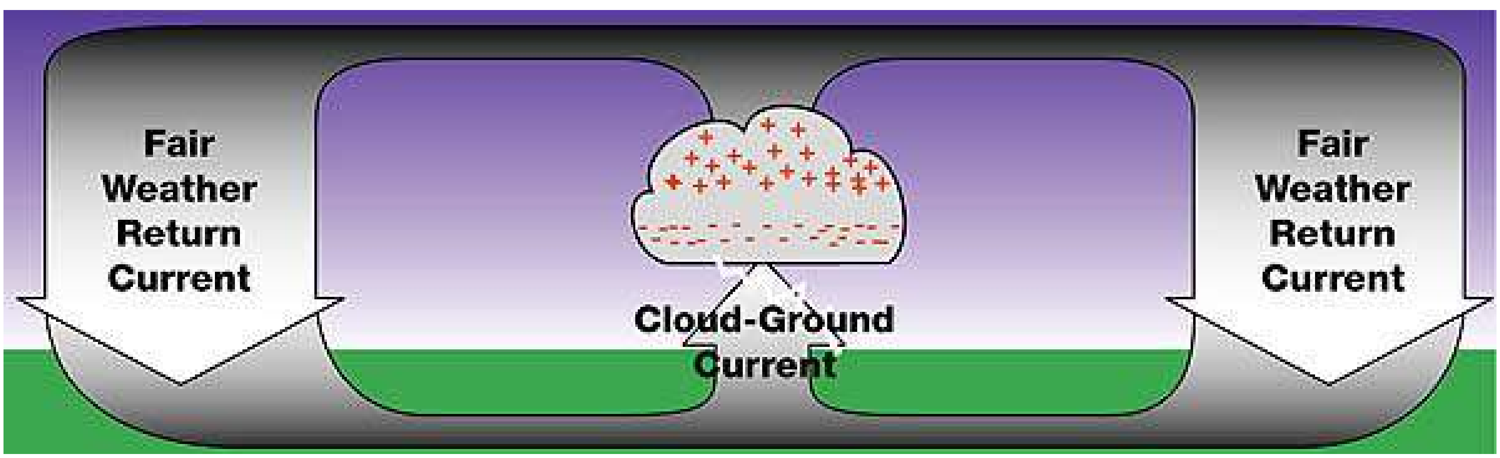
'Fair weather' measurements important to understanding thunderstorms

One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

June 15, 1999: While experts advise you to stay indoors to avoid lightning, few will tell you that you can't escape it altogether. In fact you're soaking in the return path for all the thunderstorms taking place across the world. Fortunately, the voltage is modest and the current is almost nothing, so the effect is almost impossible to measure.

"Fair weather electricity deals with the electric field and the electrical current in the atmosphere, and the conductivity of the air," explained Dr. Lothar Ruhnke of Airborne Research Associates in Weston, Mass. He recently retired from the Naval Research Laboratory but continues "doing research for fun."

The discovery of the fair weather circuit followed Ben Franklin's demonstration that lightning is caused by electricity. (Would-be experimenters take heed: Old Ben was exceptionally lucky. Others replicating his experiment have been killed, so don't try it.) Later experimenters showed that clear, calm air carries an electrical current which, it turns out is the return path for the electrical display we know as lightning.



Above: Diagram shows fair weather "circuit," showing normal potential between the ground and atmosphere. credit: NASA/MSFC (Dooling)

Its importance is noted by the title of the International Conference on Atmospheric Electricity. Much of it has focused on lightning and its effects. Thursday morning's session, co-chaired by Ruhnke, however, dealt with fair weather electricity.

Atmospheric electricity is like a massive photographic flash. An electrical charge is built up, a switch is closed, and electrons barge across a gas, ionizing it and producing light. But a flash is a complete circuit. In the case of the Earth, Ruhnke explained, the atmosphere completes the circuit.

Thunderstorm charge generation happens inside clouds. Current flows out of the tops of clouds - blue jets and red sprites may play a role - and connects with the upper atmosphere and the ionosphere. Ultimately, the current returns to Earth through the clear atmosphere. Because it's diffused over most of the globe, it's also quite weak at any given point.

"All three values are very difficult to measure," Ruhnke said. The current is 10^{-12} amps per square meter - "almost nothing." The field is about 100 volts per meter, meaning that the electric potential increases by about 200 volts from the ground to the top of Michael Jordan's head when he's standing still. Finally, air is an excellent insulator, so its conductivity is close to zero.

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"Because of all this, you don't feel anything," Ruhnke said. Even though you're standing in an electric field, your hair does not stand on end. (If you were outdoors, and it did, it would mean you're about to be hit by lightning, so tuck into a tight crouch right away.)

"When you measure the fair weather electric field, you're measuring the effects of all the thunderstorms on the Earth," he said.

But it's not evenly felt. Ruhnke said that scientists once thought the effect was evenly spread across the planet, so a measurement in Tokyo was as good as one in Kansas. It turns out that local turbulence, winds, and other fluctuations also cause small variations in the fair weather electric field.

"It's a great challenge to sort out local variations and sources from thunderstorms," Ruhnke continued. "If you could separate these effects, you could monitor the total thunderstorm activity locally."

Such a measure is important to various environmental studies, including the production of nitrous oxides (NO_x), so the relative natural and industrial

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contributions can be measured.

Another is global warming. Ruhnke noted that Ralph Markson, a colleague at Airborne Research, examined 45 years of fair weather data taken by balloons from the surface of the Earth to the stratosphere. One of the factors that affects the existence of thunderstorms in the atmosphere is temperature.

"If there is any global warming, you should see an increase in thunderstorms and the electric field," Ruhnke said. "Markson sees no changes in the ionospheric potential." Because of variations in instruments, the growth of cities, and other effects, Ruhnke said that direct measures of global warming are quite difficult.

"People are looking for indirect methods," he continued "The fair weather field is one."

Left: Thunderstorm at sunset near Abilene, Texas, May 17, 1978. Even without lightning, there's electricity in the air, although it's so weak that scientists have difficulty measuring it. (NOAA)

The fair weather field also becomes a sensor for air pollution, he noted, because aerosols - droplets and dust particles - attract and effectively neutralize ions.

He has recorded the difference in the air of Greenland and Antarctica where, 30 years ago, it was "nearly perfect" as shown by its ion content. "Now the air is fairly polluted around the globe."

In 1996, the first-ever coordinated simultaneous measurements were made for two days over Darwin, Australia, and Weston, Mass., - opposite sides of the world - to demonstrate that a single reliable measurement can be globally representative.

Ruhnke noted that fair weather conditions also are affected by the magnetosphere in the polar regions where the Earth's magnetic field leaves the upper atmosphere exposed to space. While many people have tried to link solar activity to terrestrial weather, he noted that no conclusive link has been found.

More web links

45th Weather Squadron at Patrick AFB, lightning reference page.
National Severe Storms Laboratory, Norman, OK
Numerical Modeling at NSSL
The New Mexico Tech 3D Lightning Mapping System
Lightning Detection and Ranging project at Kennedy Space Center.
National Severe Storms Laboratory Photo Library, where we got a lot of the neat pictures in these stories.

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Lightning position in storm may circle strongest updrafts

New finding could help in predicting hail, tornadoes

June 11, 1999: While lightning is one of the most dangerous aspects of severe storms, it appears that inside the storm lightning itself avoids the most violent regions. This finding has implications for tracking where tornadoes are likely to form and where large hail may fall.

One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

"This can be a monitor of severe storm intensity, another tool to monitor when storms might produce tornadoes or hail," said James Dye, a researcher at the National Center for Atmospheric Research in Boulder, Colorado. Dye spoke this week at the International Conference on Atmospheric Electricity.

Above: Time-lapse photography captures multiple cloud-to-ground lightning strokes During a night thunderstorm over Norman, Oklahoma, March, 1978. (C. Clark, NOAA)

Lightning has long been associated with convection in storms. At a simple level, the charging mechanism is similar to shuffling across the carpet on a cold winter day, then touching a door knob. The friction between your feet and the rug builds a static electric charge that you carry until you touch something grounded. Inside thunderstorms, the mechanism which separates charges is collisions between growing snow pellets and numerous ice particles.

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But storms still conceal a number of surprises in many elaborations and variations on that simple description. Dye said that scientists now are learning that the most energetic storms are prolific sources of intracloud lightning. Intracloud lightning, though obscured by the clouds, may provide another tool for monitoring severe storms.

Dye's findings come from the Stratospheric-Tropospheric Experiment: Radiation,

Aerosols and Ozone (STERAO) Deep Convection experiment in northeast Colorado in June and July 1996. He used data from a French radio interferometer that collected five hours of uninterrupted observations of the locations of lightning within two major electrical storms, and from Doppler radar that shows wind direction and speed within a storm. Combining the two data sets showed where lightning was relative to updrafts and downdrafts.

Left, Above: The main reflector for a Doppler radar, one of the principal tools for peering inside severe storms. (NSSL/NOAA)

"It seems that lightning channels themselves are not in the most intense updrafts," Dye explained, "but in the weaker updrafts and downdrafts." This would seem to go against expectation. But while the lightning avoided the updraft cores, it became more frequent around the cores as the storm grew stronger.

Dye said that storms with updrafts at speeds less than 5 meters/second (about 11 mph) produce little or no lightning. Storms with updrafts of 10 to 20 meters/second (22 to 44 mph) might have flash rates of 5 to 20 strikes per minute. At more than 40 meters/second (90 mph or more), things get busy and the flash rate goes to 1 per second or more.

Dye says no one knows sure why, but the answer probably lies in the microphysics of ice and hail formation, the separation of charges as these bodies grow and move past each other, and how they are transported inside the storms by vertical and horizontal winds.

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The French interferometer is one of several systems that have been developed in recent years to give scientists an inside view of lightning in storms. Cloud-to-ground strikes across the United States can be recorded by the National Lightning Detection Network. But intracloud strikes in local storms can be recorded only by the Lightning Detection and Ranging system at Kennedy Space Center and the Lightning Mapping System at the New Mexico Institute of Mining and Technology. Also, when they are overhead at the right time the Lightning Imaging Sensor and the Optical Transient Detector, both in orbit, can count lightning from above the clouds.

An exciting addition to this new suite of research tools would be a satellite-borne Lightning Mapping Sensor, under study at the Global Hydrology and Climate Center, that would observe the Earth continually from geostationary orbit.

"This would provide much more information in terms of intracloud strikes," he said. "It could be an additional forecasting and nowcasting tool" for meteorologists watching severe storms.

Dye cautioned that his and other results are not conclusive yet, but "they're highly suggestive and promising, but we have more work to do."

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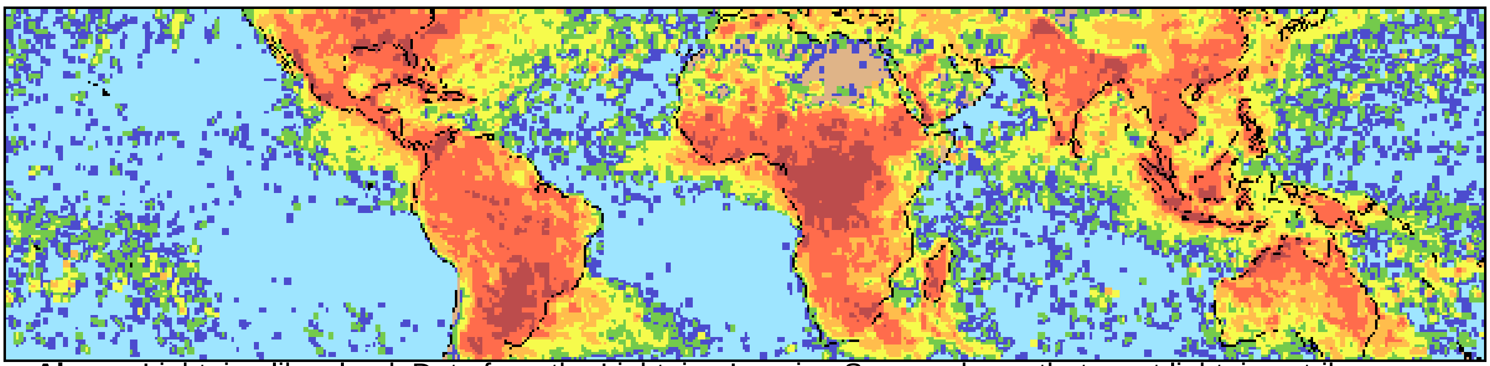
Lightning follows the Sun

Space imaging team discovers unexpected preferences

One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

June 10, 1999: Lightning not only likes land, it follows the sun, and may even change its schedule to follow the El Niño/Southern Oscillation phenomenon.

"We've been watching the global distribution and established a picture of how it changes as a function of time of day, season, and even from year to year," said Dr. Hugh Christian of the Global Hydrology and Climate Center in Huntsville, Alabama. Christian is the principal investigator for the Lightning Imaging Sensor (LIS) on the Tropical Rainfall Measuring Mission, and its predecessor, the Optical Transient Detector (OTD) on Microlab 1.

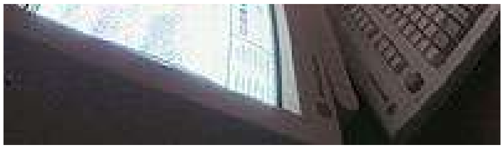


Above: Lightning likes land: Data from the Lightning Imaging Sensor shows that most lightning strikes occur over land where the ground can warm the air more effectively. This map covers the latitudes 35 deg. N to 35 deg S overflown by the Tropical Rainfall Measuring Mission carrying the LIS. Links to 937x224-pixel, 37KB GIF. (NASA/GHCC)

They provide a view of lightning from above the cloud tops, thus revealing the large percentage of cloud-to-cloud and intracloud flashes that cannot be seen from the ground. LIS and OTD both register the time of a lightning flash and its location within the instrument's field of view. This is then overlaid with weather pictures and other data so scientists can track the locations and frequency of lightning and how it corresponds with other weather phenomena.

Since their launches - OTD four years ago and LIS 18 months ago - Christian and his team have generated several maps showing global lightning patterns.

Left: At the Global Hydrology and Climate Center in Huntsville, Ala., Hugh Christian (foreground), Steve Goodman and Richard Blakeslee (background) monitor data from the Lightning Imaging Sensor aboard the Tropical Rainfall Measuring Mission. (NASA)



"Can we use lighting to monitor global change?" Christian said the team asked itself. "It does look like lightning is sensitive to changing weather patterns that evolve from year to year."

The first of these patterns to emerge was the discovery that lightning is more common in storms over land than over oceans. "It's probably a consequence of enhanced convection from increased warming over land." The LIS team announced its initial findings in 1998. Today, Christian will present expanded findings that buttress their claim.

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The team has also found that lightning prefers afternoons.

"Over land, we see tremendous diurnal changes, a strong peak in lightning in the afternoon over land," Christian continued. "Over water we see very little variation. We believe it's due to the land absorbing heat and causing strong convection. On the other hand, water can store a lot more heat, and releases it slowly."

Lightning patterns also vary from one season to the next.

"We see tremendous variations in extratropical regions," meaning areas north or south of the tropics of Cancer and Capricorn. "You see lightning activity truly following the sun. As summer in the northern hemisphere progresses, you see lightning moving farther north," Christian continued. "You see a similar pattern in the southern hemisphere, but not so pronounced because there isn't as much land outside the tropics."

Variations show up even from one year to the next. Christian said that data still being analyzed show hints that lightning patterns are influenced by El Niño and La Niña, a complementary variation in sea surface temperatures in the Pacific Ocean west of Peru. While this might be expected since El Niño can cause droughts and monsoon-like conditions, Christian said it also shows that global lightning patterns may be one way to take the pulse of the planet's weather trends.

It most certainly can be used on a small-scale, short-term basis to monitor the progress of storms.

"We can use lightning to monitor and study storms, including severe thunderstorms," Christian explained, since the lightning can only be generated by convection within a cloud system. "It's tightly coupled with the dynamics and physics of the storm. We use it to monitor its evolution and life."

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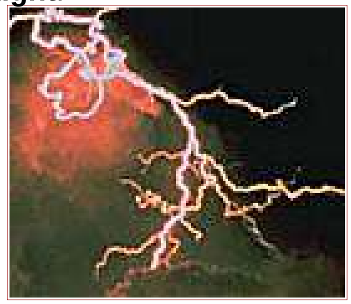
Right:



Lightning. (NOAA)

As successful as OTD and LIS have been - and are expected to be over the next 1 year and 6 years (respectively) that they are expected to continue operating - they can only be used in research. Their view is limited to a small area directly under their satellites, so global or even regional monitoring is impossible.

To fill that role, Christian and his team are studying designs for a Lightning Mapping Sensor that would be placed aboard geostationary weather satellites. From 35,680 km (22,300 mi) up, the sensor could track severe activity and enhance meteorologists' warning capabilities.

More web links

LIS primer from the Global Hydrology and Research Center

Global Hydrology and Research Center home page

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Spirits of Another Sort

Thunderstorms Generate Elusive and Mysterious Sprites

June 10, 1999: For centuries, man has been transfixed by the spectacular lightning displays of thunderstorms. But after all those years of gazing at the sky, we never realized there was an equally amazing light show going on above the clouds.

One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

In our own century, pilots reported seeing strange lights in the sky above thunderstorms. Low-light cameras on board airplanes and the Space Shuttle have recently made possible the documentation of sprites - quick red flashes of light that appear above storm clouds.

Dr. Dave Sentman of the University of Alaska, Fairbanks is one among a small group of researchers who have been studying these mysterious bursts of colored light. Although no one is sure what sprites really are or what causes them, these scientists have learned that sprites contain a great deal of energy.

"Although we're not yet certain, we suspect that the energies from sprites may be sufficient to drive some novel chemical reactions," said Sentman. "The region of the atmosphere where sprites appear typically doesn't contain a lot of energy, so the energy introduced from a sprite could do some really interesting things."

For instance, there is some speculation that sprites may create nitric oxide (NO) in the upper atmosphere. Nitric oxide destroys ozone, so sprites may have some impact on the Earth's protective ozone layer.

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Left: A red sprite with blue tendrils extending downwards. Sprites are emitted near the tops of thunderclouds and reach up into the ionosphere (40-95 km range). Credit: University of Alaska, Fairbanks.

Sentman speculated on potential sprite-generated chemical reactions at the International Conference for Atmospheric Electricity. He's hoping to entice atmospheric chemists to look at sprites and their electro-chemical byproducts. Sentman also discussed the "energy budget" of sprites, which includes the electromagnetic emissions that sprites may give off and how that energy dissipates over time. Discovered because of their visible light emissions, sprites may also give off heat (infrared) and other forms of energy.

Night Sprite Flight

Last summer, Sentman and other scientists flew above the cloud cover at night to search for sprites. Scientists from the University of Alaska cooperated with the Air Force, the Naval Research Lab and NASA on this joint flight campaign. The scientific team looked at sprite emissions ranging from ultraviolet to visible to infrared. They also looked for gravity wave interactions, carbon dioxide emissions, and nitric oxide production. Using two ground stations - one in Colorado and one in Wyoming - scientists were able to triangulate sprites for stereoscopic views.

"We flew for a two week period during moon-down," said Sentman, referring to a time period when the moon is not in the night sky. "The moon is so bright, if you get it in the field of view it can burn out low-light cameras."

The brightness of sprites is about 500 to 1,000 kiloRayleighs. The cones in the retina, which see color, can barely perceive this light level. Because the more sensitive, achromatic rods of the eye permit night vision, they can see this low light level more easily. Rods are more numerous than cones in the periphery of the retina, so you can see sprites best when you're not looking directly at them.

But because Sentman was so close to the sprites, he saw them head on. To him, the sprites were as bright as the aurora borealis (the Northern Lights).

Left: The wispy colored lights of the aurora borealis are somewhat similar in appearance to sprites.

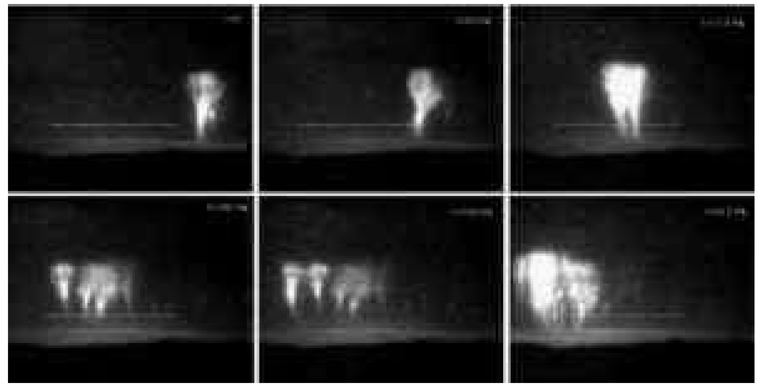
"Although younger members of the crew saw the sprite's red color, they all looked white to me," said Sentman with a rueful grin.

Sprites are brief - lasting only 3 to 10 milliseconds - and that makes them difficult to study. They are not a constant and predictable phenomena, so scientists are never sure exactly when and where sprites will appear above the storm clouds.

"Sometimes you go an entire night without seeing one - you're intently looking at the instruments all night, and you get nothing," said Sentman. "Other nights, you can see hundreds over a period of several hours. We don't know why one storm will spawn so many, while another storm remains barren."

Sentman named the phenomena "sprites" to reflect their eerie, ghost-like qualities and fleeting, elusive natures. Inspired by Shakespeare, Sentman decided on the name one wintery night over pie and coffee in a cabin near Fairbanks.

Through the house give gathering light,
By the dead and drowsy fire:
Every elf and fairy sprite
Hop as light as bird from brier;
And this ditty, after me,
Sing, and dance it trippingly.
- Wm. Shakespeare, "A Midsummer Night's Dream," Act 5, Scene 1.



Right: Time-elapsed photography shows sprites "dance" across the horizon. Credit: University of Alaska, Fairbanks.

Said Sentman, "I think William Shakespeare would have approved, if he had known of their existence."

How to Look for Sprites
(from The UAF website)

For observing sprites, it must be completely dark (not twilight) and your eyes must be dark-adapted. If you can see the Milky Way, your eyes have adapted enough to see sprites.

You need to have a clear view above a thunderstorm. Generally, this means the thunderstorm activity must be on the horizon, without any other clouds to obstruct your view. The best viewing distance from the storm is 200 to 300 km (100-200 miles). At these distances sprites will rise to a vertical distance of 10-20 degrees; 2 to 4 times the separation of the pointer stars in the Big Dipper.

Fix your gaze on the space above an active thunderstorm. To avoid being distracted by underlying lightning activity, you may want to use a piece of paper to block out the area below the clouds.

Left: Black & white images of multiple sprites seen in October, 1997. Credit: New Mexico Tech/NASA.

The bright lights of a city or cloud illumination from lightning may prevent you from seeing sprites.

Sprites are brief - only 3 to 10 milliseconds. They occur too quickly to follow with the eyes, but their vertical structure and red color may be perceived.

Patience will be rewarded. If the right kind of storm is present and one's viewing geometry is favorable, there is a greater likelihood of seeing a sprite than of seeing a shooting star.

If you DO see a sprite (or any other kind of optical emission above a thunderstorm) please report it!

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More web links

University of Alaska, Fairbanks - Sprite research home page.

Red Sprites and Blue Jets - an older page maintained by UAF.

Los Alamos National Laboratory - computer models of sprites.

NASA's sprite page

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Getting a solid view of lightning

New Mexico team develops system to depict lightning in three dimensions

One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

June 9, 1999: The bolt snakes out of the cloud, traces a jagged path left or right across the sky, and touches the ground. Or does it?

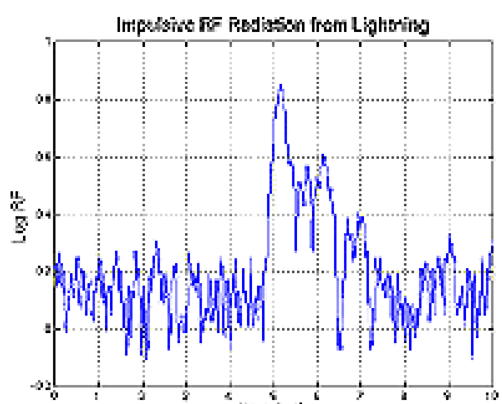
For most of us observing lightning - from a safe distance or inside a building - a lightning bolt is a flat, two-dimensional creature painted against a distant backdrop. But as researchers have shown over the last three decades, lightning has a complex shape that may let scientist pry a few secrets from a storm - including where a tornado might form.

Left: Just a bolt straight down? Is it pointing towards the viewer, or away? And what about the big ones that get away, the cloud-to-cloud flashes that are not seen on the ground? Credit: NOAA

A number of techniques have been developed over the years to look at the 3-D structure," said William Rison of the New Mexico Institute of Mining and Technology in Socorro, N.M. Rison works with Paul Krehbiel who talks today about "3-D Lightning Mapping and Observations" at the International Atmospheric Electricity Conference in Guntersville.

"The primary method is time of arrival of the radio signal," Rison continued. Besides a blinding flash of visible light, a lightning bolt also emits a distinct pulse of radio noise. The background crackle you hear on AM radio is the sound of distant lightning.

If several radio receivers are set up to record the radio pulse with precision timing, then the location of the pulse origin can be backtracked with a little math. It's similar to the principle used in navigating by satellite where several satellite broadcast the same timing signal and are heard, at different times (depending on distance) by a receiver.



Right: A typical radio waveform for a lightning bolt. The large peak is what scientists want to record. The lower peaks are noise, some caused by lightning from distant storms. Links to 556x413-pixel, 9KB GIF. Credit: New Mexico Tech.

The time of arrival method was pioneered in the 1960s by David Proctor of South Africa using VHF radio receivers. His work was laborious, with the data being collated and analyzed by hand.

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In the 1970s and '80s, the technique was expanded by Carl Lennon and Launa Maier at NASA's Kennedy Space Center who developed a real-time system linked by microwave relays. This lets meteorologists tell launch directors if an electrical storm is too close for a safe launch. It's also optimized for Florida thunderstorms that are different in structure from what is seen in the central United States, and the microwave relays are bulky and difficult to move for studies in different areas.

Above: Negative leaders - lightning moving upward from negatively to positively charged regions in a cloud - are readily detected by radio techniques. Positive leaders are rarely observed. What sometimes appears to be a positive leader is actually an inverted cloud where the negative charges are at the top and positive charges are below. A negative step leader in a cloud-to-ground strike is not impulsive but continuous, making it difficult to detect by time-of-arrival methods. Credit: NASA/Marshall

By adapting a number of new technologies, Krehbiel and his colleagues have developed a Lightning Mapping System that can provide real-time 3-D images of lightning as storms develop.

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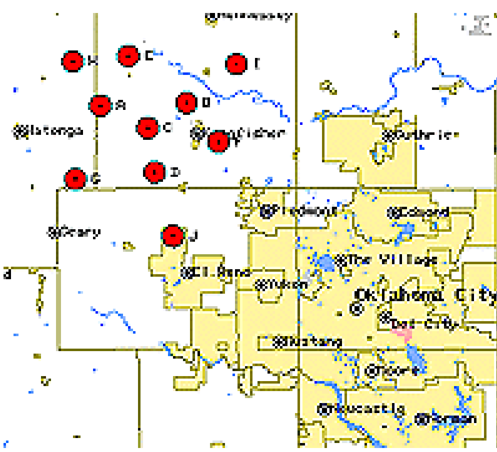
Rison said the system comprises 10 automated ground stations, each with a radio receiver, a precision clock developed for satellite navigation receivers, a signal processor to extract and time-tag just the lightning pulse, and tape recorder. In two field campaigns, the network was set up northwest of Oklahoma City in June 1998 and outside Socorro in August 1998. It is scheduled for another campaign in New Mexico in the summer of 1999 and the Nebraska-Kansas-Colorado area the summer of 2000.



Left: Red dots mark where the Lightning Mapping System receivers were positioned outside Oklahoma City for field tests. Norman, Okla., home of the National Sever Storms Laboratory, is in the lower right corner of this map. Links to 800x600-pixel, 24KB GIF. Credit: New Mexico Tech.

After a storm, the data tapes are collected and sent to Krehbiel's team. They then produce 3-D plots showing a lightning bolt's trip through a storm.

"This gives you, with a few qualifications, the full flash," Rison said. The principal qualification is that the system is most sensitive to negative streamers, discharges in which a stream of electrons burrows its way through the air to a positively charged area.

Time of arrival techniques locate impulsive radio emissions. This happens most often with negative leaders propagating into negative charge regions. It does not locate positive leaders into negative charge regions because the positive leaders do not radiate strongly. It often does not locate negative stripped leaders of cloud-to-ground lightning. These radiate strongly but are continuous, not impulsive.

As the lightning streaks across the sky, it ionizes new points in the air. In effect, the transmitter is moving through the sky, sending a new signal from each point. Each is recorded and, when the storm is reconstructed in a computer, becomes an individual point in a three-dimensional grid. The points are color coded to help the human eye follow a bolt's path across the sky. The positional accuracy is best when the storm is close to the array of receivers, but is still good out to ranges of 250 km (155 mi).

Web Links
Human Voltage (June 18, 1999) Scientists discuss biology, safety, and statistics of lightning strikes. News shorts from Atmospheric Electricity Conference (June 16, 1999) Poster papers on hurricanes and tornadoes summarized. Soaking in atmospheric electricity (June 15, 1999) 'Fair weather' measurements important to understanding thunderstorms. Lightning position in storm may circle strongest updrafts (June 11, 1999) New finding could help in predicting hail, tornadoes Lightning follows the Sun (June 10, 1999) Space imaging team discovers unexpected preferences Spirits of another sort (June 10, 1999) Thunderstorms generate elusive and mysterious sprites. Getting a solid view of lightning (June 9, 1999): New Mexico team develops system to depict lightning in three dimensions. Learning how to diagnose bad flying weather (June 8, 1999): Scientists discuss what they know about lightning's effects on spacecraft and aircraft. Three bolts from the blue (June 8, 1999): Fundamental questions about atmospheric electricity posed at conference this week. Lightning Leaders Converge in Alabama (May 24, 1999): Preview of the 11th International Conference on Atmospheric Electricity. What Comes Out of the Top of a Thunderstorm? (May 26, 1999): Gamma-rays (sometimes). **Lightning research** at NASA/Marshall and the Global Hydrology and Climate Center.

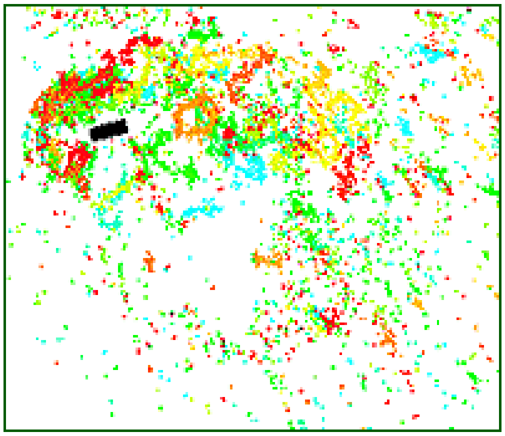
The data plots also can be used to show where lightning occurs most often within a storm, matching lightning activity to storm structure, including convection.

The results are impressive and highly promising, Rison said.

"The initial discharge goes up," he said, describing one bolt recorded during a July 11, 1998, storm. The negative charge was at about 6 km altitude, and the positive charge was at 9 to 10 km. When discharge occurred when electric potential between the two regions became great enough to ionize a channel through air and become as conductive as a metal wire.

"Once that channel is established, then the discharge continued in the horizontal direction," he said. The upper charge center expanded east-west, and the lower center expanded north-south. Like snowflakes, each bolt is unique. "It depends on the structure of the cloud."

Storms also are unique. While some spit lightning at a seemingly leisurely pace, others are like hailstones hitting the roof. One supercell storm outside Oklahoma City fired almost nonstop.



Right: The black patch in this plot of lightning indicates that path of a tornado that formed in Oklahoma on June 13, 1998. The Lightning Mapping System did not see the tornado itself, but shows lightning snaking around the strong convective core that spawned the twister. Links to 570x720-pixel, 40KB GIF. Credit: New Mexico Tech.

"There was no time without lightning," Rison said. "The data are very amorphous. It just fills the plot and appears to be continuous. There's no gap in between. It's a real challenge to sort out. You can see tendrils, but not the start of one discharge and the start of another. That hasn't been seen before."

On the other hand, the Lightning Mapping System has recorded storms with apparent dead zones, where almost no lightning appears. But these are not hurricane-like eyes of the storm.

"That's a region of a very strong updraft moving at about 100 to 160 km/h (60-100 mph), vertically," Rison said. Storm watchers observed "a very high turret penetrating to the stratosphere." A little lightning does appear at extreme altitudes.

"We see clear evidence of an updraft," he continued. "We see continued discharging that has to be explained somehow." In this case, no tornado appeared. But Rison and his team have seen lightning dead spots where tornadoes did appear.

"The lightning wraps itself around the area where the tornado formed," he said. "This is where a hook echo forms on radar."

Left: Another portion of the June 13, 1998, storm shows an "eye" that isn't - it's a strongly convective core where only sparse lightning (blue circle) occurs, and that's at the top of the core, as seen in the cross-section at right. Links to 570x720-pixel, 64KB GIF Credit: New Mexico Tech.

Radar is the tool that is needed now to complement studies with the Lightning Mapping System. Observations with two or more Doppler radar units would provide three-dimensional data on wind speed and direction.

New Mexico Tech is talking with the Global Hydrology and Climate Center in Huntsville about establishing a system in Huntsville, and with the Federal Aviation Administration, National Severe Storms Laboratory, and Global Atmospheric Inc., about setting up a prototype unit at the Dallas-Forth Worth Airport.

More web links

More Space Science Headlines - NASA research on the web
NASA's Earth Science Enterprise Information on Earth Science missions, etc.

External links

45th Weather Squadron at Patrick AFB, lightning reference page.
National Severe Storms Laboratory, Norman, OK
Numerical Modeling at NSSL
The New Mexico Tech 3D Lightning Mapping System
Lightning Detection and Ranging project at Kennedy Space Center.
National Severe Storms Laboratory Photo Library, where we got a lot of the neat pictures in these stories.

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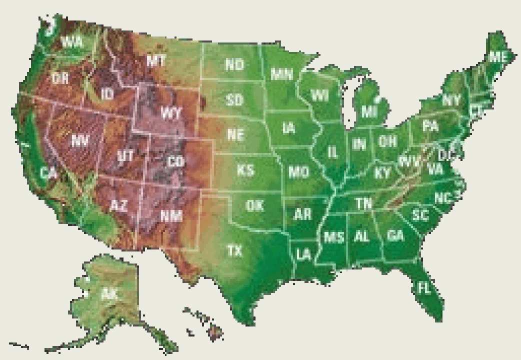

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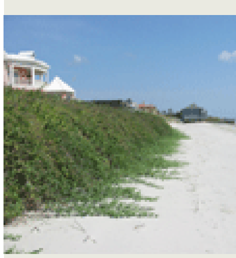
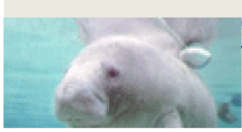


For this Plant, Life´s a Beach:

This plant is living it up, lying out on the sand, soaking up the sun, practically making the beach its own--literally. Beach vitex, which has been dubbed "beach kudzu," is a pesky invasive plant species that is taking over the beaches of South Carolina. Read more . . .



The Mark of Zorro, Manatee-style:

Much like the identifying Z etched on Zorro´s face, the pattern of scars on different manatees helps scientists tell something about them and distinguish them from

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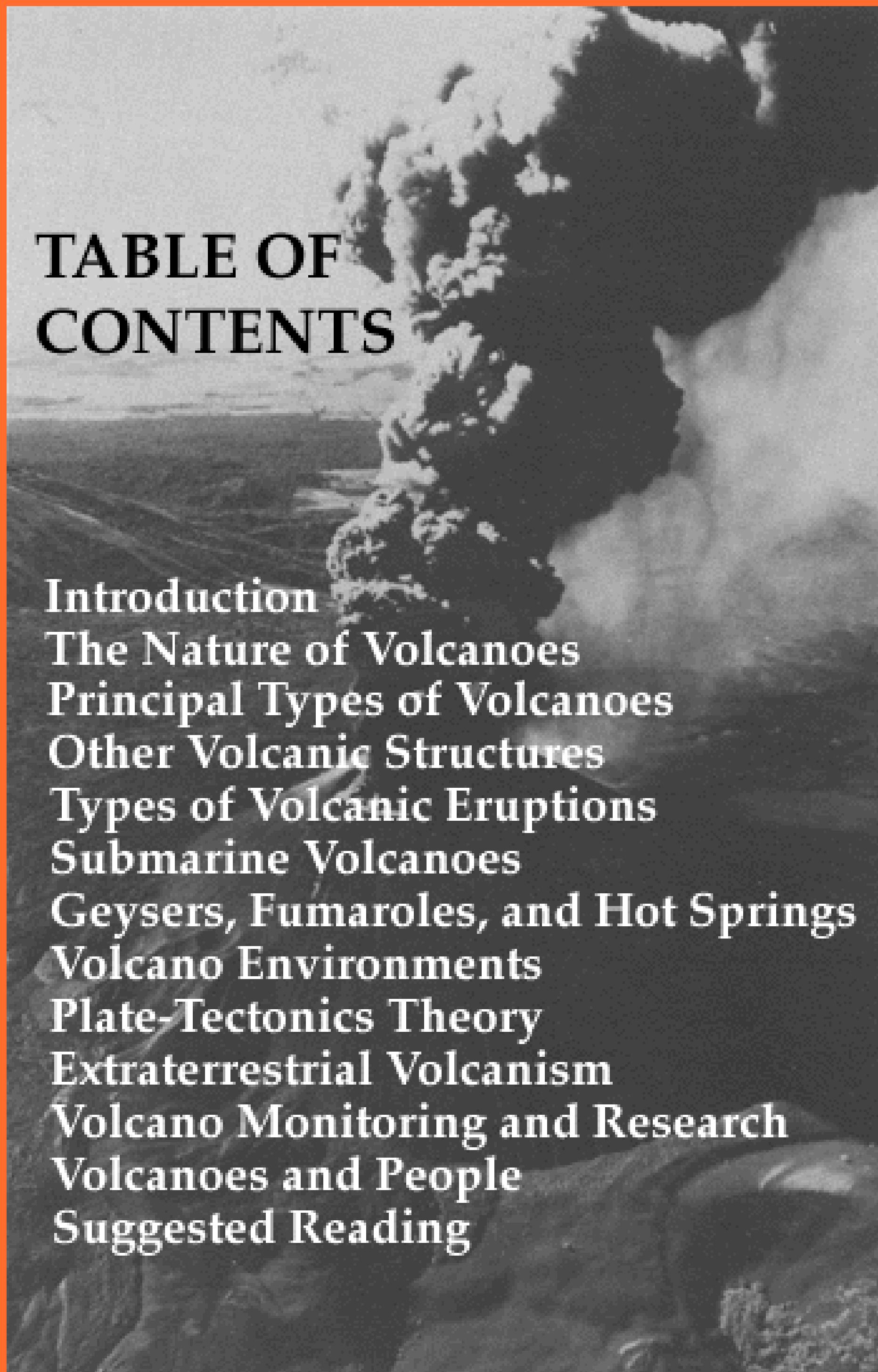

The eruption of Cerro Negro Volcano, near Leon, Nicaragua, during November 1968.

This on-line edition contains all text from the original book in its entirety. Some figures have been modified to enhance legibility at screen resolutions.

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VOLCANOES

By *Robert I. Tilling*

[Text with graphics]

Volcanoes destroy and volcanoes create. The catastrophic eruption of Mount St. Helens on May 18, 1980, made clear the awesome destructive power of a volcano. Yet, over a time span longer than human memory and record, volcanoes have played a key role in forming and modifying the planet upon which we live. More than 80 percent of the Earth's surface--above and below sea level--is of volcanic origin. Gaseous emissions from volcanic vents over hundreds of millions of years formed the Earth's earliest oceans and atmosphere, which supplied the ingredients vital to evolve and sustain life. Over geologic eons, countless volcanic eruptions have produced mountains, plateaus, and plains, which subsequent erosion and weathering have sculpted into majestic landscapes and formed fertile soils.

Ironically, these volcanic soils and inviting terranes have attracted, and continue to attract, people to live on the flanks of volcanoes. Thus, as population density increases in regions of active or potentially active volcanoes, mankind must become increasingly aware of the hazards and learn not to "crowd" the volcanoes. People living in the shadow of volcanoes must live in harmony with them and expect, and should plan for, periodic violent unleashings of their pent-up energy.

This booklet presents a generalized summary of the nature, workings, products, and hazards of the common types of volcanoes around the world, along with a brief introduction to the techniques of volcano monitoring and research.

On August 24, A.D. 79, Vesuvius Volcano suddenly exploded and destroyed the Roman cities of Pompeii and Herculaneum. Although Vesuvius had shown stir-rings of life when a succession`of earthquakes in A.D. 63 caused some damage, it had been literally quiet for hundreds of years and was considered "extinct." Its surface and crater were green and covered with vegetation, so the eruption was totally unexpected. Yet in a few hours, hot volcanic ash and dust buried the two cities so thoroughly that their ruins were not uncovered for nearly 1,700 years, when the discovery of an outer wall in 1748 started a period of modern archeology. Vesuvius has continued its activity intermittently ever since A.D 79 with numerous minor eruptions and several major eruptions occurring in 1631, 1794, 1872, 1906 and in 1944 in the midst of the Italian campaign of World War II.

In the United States on March 27, 1980, Mount St. Helens Volcano in the Cascade Range, southwestern Washington, reawakened after more than a century of dormancy and provided a dramatic and tragic reminder that there are active volcanoes in the "lower 48" States as well as in Hawaii and Alaska.The catastrophic eruption of Mount St. Helens on May 18, 1980, and related mudflows and flooding caused significant loss of life (57 dead or missing) and property damage over $1.2 billion). Mount St. Helens is expected to remain intermittently active for months or years, possibly even decades.

The word volcano comes from the little island of Vulcano in the Mediterranean Sea off Sicily. Centuries ago, the people living in this area believed that Vulcano was the chimney of the forge of Vulcan--the blacksmith of the Roman gods. They thought that the hot lava fragments and clouds of dust erupting from Vulcano came from Vulcan's forge as he beat out thunderbolts for Jupiter, king of the gods, and weapons for Mars, the god of war. In Polynesia the people attributed eruptive activity to the beautiful but wrathful Pele, Goddess of Volcanoes, whenever she was angry or spiteful. Today we know that volcanic eruptions are not super natural but can be studied and interpreted by scientists.

The Nature of Volcanoes

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Volcanoes are mountains but they are very different from other mountains. They are not formed by folding and crumpling but by uplift and erosion. Instead, volcanoes are built by the accumulation of their own eruptive products--lava, bombs (crusted over ash flows, and tephra (airborne ash and dust). A volcano is most commonly a conical hill or mountain built around a vent that connects with reservoirs of molten rock below the surface of the Earth . The term *volcano* also refers to the opening or vent through which the molten rock and associated gases are expelled.

Driven by buoyancy and gas pressure the molten rock, which is lighter than the surrounding solid rock forces its way upward and may ultimately break though zones of weaknesses in the Earth's crust. If so, an eruption begins, and the molten rock may pour from the vent as non-explosive lava flows, or if may shoot violently into the air as dense clouds of lava fragments. Larger fragments fall back around the vent, and accumulations of fall-back fragments may move downslope as ash flows under the force of gravity. Some of the finer ejected materiaIs may be carried by the wind only to fall to the ground many miles away. The finest ash particles may be injected miles into the atmosphere and carried many times around the world by stratospheric winds before settling out.

Molten rock below the surface of the Earth that rises in volcanic vents is known as *magma*, but after it erupts from a volcano it is called *lava*. Originating many tens of miles beneath the ground, the ascending magma commonly contains some crystals, fragments of surrounding (unmelted) rocks, and dissolved gases, but it is primarily a liquid composed principally of oxygen, silicon, aluminum, iron, magnesium, calcium, sodium, potassium, titanium, and manganese. Magmas also contain many other chemical elements in trace quantities. Upon cooling, the liquid magma may precipitate crystals of various minerals until solidification is complete to form an *igneous* or *magmatic* rock.

The diagram below shows that heat concentrated in the Earth's upper *mantle* raises temperatures sufficiently to melt the rock locally by fusing the materials with the lowest melting temperatures, resulting in small, isolated blobs of magma. These blobs then collect, rise through conduits and fractures, and some ultimately may re-collect in larger pockets or reservoirs ("holding tanks") a few miles beneath the Earth's surface. Mounting pressure within the reservoir may drive the magma further upward through structurally weak zones to erupt as lava at the surface. In a continental environment, magmas are generated in the Earth's crust as well as at varying depths in the upper mantle. The variety of molten rocks in the crust, plus the possibility of mixing with molten materials from the underlying mantle, leads to the production of magmas with widely different chemical compositions.

If magmas cool rapidly, as might be expected near or on the Earth's surface, they solidify to form igneous rocks that are finely crystalline or glassy with few crystals. Accordingly, lavas, which of course are very rapidly cooled, form volcanic rocks typically characterized by a small percentage of crystals or fragments set in a matrix of *glass* (quenched or super-cooled magma) or finer grained crystalline materials. If magmas never breach the surface to erupt and remain deep underground, they cool much more slowly and thus allow ample time to sustain crystal precipitation and growth, resulting in the formation of coarser grained, nearly completely crystalline, igneous rocks. Subsequent to final crystallization and solidification, such rocks can be exhumed by erosion many thousands or millions of years later and be exposed as large bodies of so-called *granitic* rocks, as, for example, those spectacularly displayed in Yosemite National Park and other parts of the majestic Sierra Nevada mountains of California.

Lava is red hot when it pours or blasts out of a vent but soon changes to dark red, gray, black, or some other color as it cools and solidifies. Very hot, gas-rich lava containing abundant iron and magnesium is fluid and flows like hot tar, whereas cooler, gas-poor lava high in silicon, sodium, and potassium flows sluggishly, like thick honey in some cases or in others like pasty, blocky masses.

All magmas contain dissolved gases, and as they rise to the surface to erupt, the confining pressures are reduced and the dissolved gases are liberated either quietly or explosively. If the lava is a thin fluid (not viscous), the gases may escape easily. But if the lava is thick and pasty (highly viscous), the gases will not move freely but will build up tremendous pressure, and ultimately escape with explosive violence. Gases in lava may be compared with the gas in a bottle of a carbonated soft drink. If you put your thumb over the top of the bottle and shake it vigorously, the gas separates from the drink and forms bubbles. When you remove your thumb abruptly, there is a miniature explosion of gas and liquid. The gases in lava behave in somewhat the same way. Their sudden expansion causes the terrible explosions that throw out great masses of solid rock as well as lava, dust, and ashes.

The violent separation of gas from lava may produce rock froth called *pumice*. Some of this froth is so light--because of the many gas bubbles--that it floats on water. In many eruptions, the froth is shattered explosively into small fragments that are hurled high into the air in the form of volcanic cinders (red or black), volcanic ash (commonly tan or gray), and volcanic dust.

Principal Types of Volcanoes

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Geologists generally group volcanoes into four main kinds--cinder cones, composite volcanoes, shield volcanoes, and lava domes.

Cinder cones

Cinder cones are the simplest type of volcano. They are built from particles and blobs of congealed lava ejected from a single vent. As the gas-charged lava is blown violently into the air, it breaks into small fragments that solidify and fall as *cinders* around the vent to form a circular or oval cone. Most cinder cones have a bowl-shaped *crater* at the summit and rarely rise more than a thousand feet or so above their surroundings. Cinder cones are numerous in western North America as well as throughout other volcanic terrains of the world.

In 1943 a cinder cone started growing on a farm near the village of Parícutin in Mexico. Explosive eruptions caused by gas rapidly expanding and escaping from molten lava formed cinders that fell back around the vent, building up the cone to a height of 1,200 feet. The last explosive eruption left a funnel-shaped crater at the top of the cone. After the excess gases had largely dissipated, the molten rock quietly poured out on the surrounding surface of the cone and moved downslope as lava flows. This order of events--eruption, formation of cone and crater, lava flow--is a common sequence in the formation of cinder cones.

During 9 years of activity, Parícutin built a prominent cone, covered about 100 square miles with ashes, and destroyed the town of San Juan. Geologists from many parts of the world studied Parícutin during its lifetime and learned a great deal about volcanism, its products, and the modification of a volcanic landform by erosion.

Composite volcanoes

Some of the Earth's grandest mountains are *composite* volcanoes--sometimes called *stratovolcanoes*. They are typically steep-sided, symmetrical cones of large dimension built of alternating layers of lava flows, volcanic ash, cinders, blocks, and bombs and may rise as much as 8,000 feet above their bases. Some of the most conspicuous and beautiful mountains in the world are composite volcanoes, including Mount Fuji in Japan, Mount Cotopaxi in Ecuador, Mount Shasta in California, Mount Hood in Oregon, and Mount St. Helens and Mount Rainier in Washington.

Most composite volcanoes have a crater at the summit which contains a central vent or a clustered group of vents. Lavas either flow through breaks in the crater wall or issue from fissures on the flanks of the cone. Lava, solidified within the fissures, forms dikes that act as ribs which greatly strengthen the cone.

The essential feature of a composite volcano is a conduit system through which magma from a reservoir deep in the Earth's crust rises to the surface. The volcano is built up by the accumulation of material erupted through the conduit and increases in size as lava, cinders, ash, etc., are added to its slopes.

When a composite volcano becomes dormant, erosion begins to destroy the cone. As the cone is stripped away, the hardened magma filling the conduit (the volcanic plug) and fissures (the dikes) becomes exposed, and it too is slowly reduced by erosion. Finally, all that remains is the plug and dike complex projecting above the land surface--a telltale remnant of the vanished volcano.

An interesting variation of a composite volcano can be seen at Crater Lake in Oregon. From what geologists can interpret of its past, a high volcano--called Mount Mazama- probably similar in appearance to present-day Mount Rainier was once located at this spot. Following a series of tremendous explosions about 6,800 years ago, the volcano lost its top. Enormous volumes of volcanic ash and dust were expelled and swept down the slopes as ash flows and avalanches. These large-volume explosions rapidly drained the lava beneath the mountain and weakened the upper part. The top then collapsed to form a large depression, which later filled with water and is now completely occupied by beautiful Crater Lake. A last gasp of eruptions produced a small cinder cone, which rises above the water surface as Wizard Island near the rim of the lake. Depressions such as Crater Lake, formed by collapse of volcanoes, are known as *calderas*. They are usually large, steep-walled, basin-shaped depressions formed by the collapse of a large area over, and around, a volcanic vent or vents. Calderas range in form and size from roughly circular depressions 1 to 15 miles in diameter to huge elongated depressions as much as 60 miles long.

Shield volcanoes

Shield volcanoes, the third type of volcano, are built almost entirely of fluid lava flows. Flow after flow pours out in all directions from a central summit vent, or group of vents, building a broad, gently sloping cone of flat, domical shape, with a profile much like that of a warrior's shield. They are built up slowly by the accretion of thousands of highly fluid lava flows called basalt lava that spread widely over great distances, and then cool as thin, gently dipping sheets. Lavas also commonly erupt from vents along fractures (rift zones) that develop on the flanks of the cone. Some of the largest volcanoes in the world are shield volcanoes. In northern California and Oregon, many shield volcanoes have diameters of 3 or 4 miles and heights of 1,500 to 2,000 feet. The Hawaiian Islands are composed of linear chains of these volcanoes including Kilauea and Mauna Loa on the island of Hawaii-- two of the world's most active volcanoes. The floor of the ocean is more than 15,000 feet deep at the bases of the islands. As Mauna Loa, the largest of the shield volcanoes (and also the world's largest active volcano), projects 13,677 feet above sea level, its top is over 28,000 feet above the deep ocean floor.

In some eruptions, basaltic lava pours out quietly from long fissures instead of central vents and floods the surrounding countryside with lava flow upon lava flow, forming broad plateaus. Lava plateaus of this type can be seen in Iceland, southeastern Washington, eastern Oregon, and southern Idaho. Along the Snake River in Idaho, and the Columbia River in Washington and Oregon, these lava flows are beautifully exposed and measure more than a mile in total thickness.

Lava domes

Volcanic or lava domes are formed by relatively small, bulbous masses of lava too viscous to flow any great distance; consequently, on extrusion, the lava piles over and around its vent. A dome grows largely by expansion from within. As it grows its outer surface cools and hardens, then shatters, spilling loose fragments down its sides. Some domes form craggy knobs or spines over the volcanic vent, whereas others form short, steep-sided lava flows known as "coulees." Volcanic domes commonly occur within the craters or on the flanks of large composite volcanoes. The nearly circular Novarupta Dome that formed during the 1912 eruption of Katmai Volcano, Alaska, measures 800 feet across and 200 feet high. The internal structure of this dome--defined by layering of lava fanning upward and outward from the center--indicates that it grew largely by expansion from within. Mont Pelée in Martinique, Lesser Antilles, and Lassen Peak and Mono domes in California are examples of lava domes. An extremely destructive eruption accompanied the growth of a dome at Mont Pelée in 1902. The coastal town of St. Pierre, about 4 miles downslope to the south, was demolished and nearly 30,000 inhabitants were killed by an incandescent, high-velocity ash flow and associated hot gases and volcanic dust.

Only two men survived; one because he was in a poorly ventilated, dungeon-like jail cell and the other who somehow made his way safely through the burning city.

Other Volcanic Structures

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Plugs (necks)

Congealed magma, along with fragmental volcanic and wallrock materials, can be preserved in the feeding conduits of a volcano upon cessation of activity. These preserved rocks form crudely cylindrical masses, from which project radiating dikes; they may be visualized as the fossil remains of the innards of a volcano (the so-called "volcanic plumbing system") and are referred to as volcanic *plugs* or *necks*. The igneous material in a plug may have a range of composition similar to that of associated lavas or ash, but may also include fragments and blocks of denser, coarser grained rocks-- higher in iron and magnesium, lower in silicon--thought to be samples of the Earth's deep crust or upper mantle plucked and transported by the ascending magma. Many plugs and necks are largely or wholly composed of fragmental volcanic material and of fragments of wallrock, which can be of any type. Plugs that bear a particularly strong imprint of explosive eruption of highly gas-charged magma are called *diatremes* or *tuff-breccia*.

Volcanic plugs are believed to overlie a body of magma which could be either still largely liquid or completely solid depending on the state of activity of the volcano. Plugs are known, or postulated, to be commonly funnel shaped and to taper downward into bodies increasingly elliptical in plan or elongated to dike-like forms. Typically, volcanic plugs and necks tend to be more resistant to erosion than their enclosing rock formations. Thus, after the volcano becomes inactive and deeply eroded, the exhumed plug may stand up in bold relief as an irregular, columnar structure. One of the best known and most spectacular diatremes in the United States is Ship Rock in New Mexico, which towers some 1,700 feet above the more deeply eroded surrounding plains. Volcanic plugs, including diatremes, are found elsewhere in the western United States and also in Germany, South Africa, Tanzania, and Siberia.

Maars

Also called "tuff cones," *maars* are shallow, flat-floored craters that scientists interpret have formed above diatremes as a result of a violent expansion of magmatic gas or steam; deep erosion of a maar presumably would expose a diatreme. Maars range in size from 200 to 6,500 feet across and from 30 to 650 feet deep, and most are commonly filled with water to form natural lakes. Most maars have low rims composed of a mixture of loose fragments of volcanic rock and rocks torn from the walls of the diatreme.

Maars occur in the western United States, in the Eifel region of Germany, and in other geologically young volcanic regions of the world. An excellent example of a maar is Zuni Salt Lake in New Mexico, a shallow saline lake that occupies a flat-floored crater about 6,500 feet across and 400 feet deep. Its low rim is composed of loose pieces of basaltic lava and wallrocks (sandstone, shale, limestone) of the underlying diatreme, as well as random chunks of ancient crystalline rocks blasted upward from great depths.

Nonvolcanic craters

Some well-exposed, nearly circular areas of intensely deformed sedimentary rocks, in which a central vent-like feature is surrounded by a ring-shaped depression, resemble volcanic structures in gross form. As no clear evidence of volcanic origin could be found in or near these structures, scientists initially described them as "cryptovolcanic," a term now rarely used. Recent studies have shown that not all craters are of volcanic origin. Impact craters, formed by collisions with the Earth of large meteorites, asteroids, or comets, share with volcanoes the imprints of violent origin, as evidenced by severe disruption, and even local melting, of rock. Fragments of meteorites or chemically detectable traces of extraterrestrial materials and indications of strong forces acting from above, rather than from below, distinguish impact from volcanic features.

Other possible explanations for these nonvolcanic craters include subsurface salt-dome intrusion (and subsequent dissolution and collapse caused by subsurface limestone dissolution and/or ground-water withdrawal; and collapse related to melting of glacial ice. An impressive example of an impact structure is Meteor Crater, Ariz., which is visited by thousands of tourists each year. This impact crater, 4,000 feet in diameter and 600 feet deep, was formed in the geologic past (probably 30,00050,000 years before present) by a meteorite striking the Earth at a speed of many thousands of miles per hour.

In addition to Meteor Crater, very fresh, morphologically distinct, impact craters are found at three sites near Odessa, Tex., as well as 10 or 12 other locations in the world. Of the more deeply eroded, less obvious, postulated impact structures, there are about ten well-established sites in the United States and perhaps 80 or ~0 elsewhere in the world.

Types of Volcanic Eruptions

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During an episode of activity, a volcano commonly displays a distinctive pattern of behavior. Some mild eruptions merely discharge steam and other gases, whereas other eruptions quietly extrude quantities of lava. The most spectacular eruptions consist of violent explosions that blast great clouds of gas-laden debris into the atmosphere.

The type of volcanic eruption Is often labeled with the name of a well-known volcano where characteristic behavior is similar--hence the use of such terms as "Strombolian," "Vulcanian," "Vesuvian," "Pelean," "Hawaiian," and others. Some volcanoes may exhibit only one characteristic type of eruption during an interval of activity--others may display an entire sequence of types.

In a Strombolian-type eruption observed during the 1965 activity of Irazu Volcano in Costa Rica, huge clots of molten lava burst from the summit crater to form luminous arcs through the sky. Collecting on the flanks of the cone, lava clots combined to stream down the slopes in fiery rivulets.

In contrast, the eruptive activity of Parícutin Volcano in 1947 demonstrated a "Vulcanian"-type eruption, in which a dense cloud of ash-laden gas explodes from the crater and rises high above the peak. Steaming ash forms a whitish cloud near the upper level of the cone.

In a "Vesuvian" eruption, as typified by the eruption of Mount Vesuvius in Italy in A.D. 79, great quantities of ash-laden gas are violently discharged to form cauliflower-shaped cloud high above the volcano.

In a "Peléan" or "Nuée Ardente (glowing cloud) eruption, such as occurred on the Mayon Volcano in the Philippines in 1968, a large quantity of gas, dust, ash, and incandescent lava fragments are blown out of a central crater, fall back, and form tongue-like, glowing avalanches that move downslope at velocities as great as 100 miles per hour. Such eruptive activity can cause great destruction and loss of life if it occurs in populated areas, as demonstrated by the devastation of St. Pierre during the 1902 eruption of Mont Pelée on Martinique, Lesser Antilles.

"Hawaiian" eruptions may occur along fissures or fractures that serve as linear vents, such as during the eruption of Mauna Loa Volcano in Hawaii in 1950; or they may occur at a central vent such as during the 1959 eruption in Kilauea Iki Crater of Kilauea Volcano, Hawaii. In fissure-type eruptions, molten, incandescent lava spurts from a fissure on the volcano's rift zone and feeds lava streams that flow downslope. In central-vent eruptions, a fountain of fiery lava spurts to a height of several hundred feet or more. Such lava may collect in old pit craters to form lava lakes, or form cones, or feed radiating flows.

"Phreatic" (or steam-blast) eruptions are driven by explosive expanding steam resulting from cold ground or surface water coming into contact with hot rock or magma. The distinguishing feature of phreatic explosions is that they only blast out fragments of preexisting solid rock from the volcanic conduit; no new magma is erupted. Phreatic activity is generally weak, but can be quite violent in some cases, such as the 1965 eruption of Taal Volcano, Philippines, and the 1975-76 activity at La Soufrière, Guadeloupe (Lesser Antilles).

The most powerful eruptions are called "plinian" and involve the explosive ejection of relatively viscous lava. Large plinian eruptions--such as during 18 May 1980 at Mount St. Helens or, more recently, during 15 June 1991 at Pinatubo in the Philippines--can send ash and volcanic gas tens of miles into the air. The resulting ash fallout can affect large areas hundreds of miles downwind. Fast-moving deadly pyroclastic flows ("nuées ardentes") are also commonly associated with plinian eruptions.

Submarine Volcanoes

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Submarine volcanoes and volcanic vents are common features on certain zones of the ocean floor. Some are active at the present time and, in shallow water, disclose their presence by blasting steam and rock-debris high above the surface of the sea. Many others lie at such great depths that the tremendous weight of the water above them results in high, confining pressure and prevents the formation and explosive release of steam and gases. Even very large, deep-water eruptions may not disturb the ocean surface.

The unlimited supply of water surrounding submarine volcanoes can cause them to behave differently from volcanoes on land. Violent, steam-blast eruptions take place when sea water pours into active shallow submarine vents. Lava, erupting onto a shallow sea floor or flowing into the sea from land, may cool so rapidly that it shatters into sand and rubble. The result is the production of huge amounts of fragmental volcanic debris. The famous "black sand" beaches of Hawaii were created virtually instantaneously by the violent interaction between hot lava and sea water. On the other hand, recent observations made from deep-diving submersibles have shown that some submarine eruptions produce flows and other volcanic structures remarkably similar to those formed on land. Recent studies have revealed the presence of spectacular, high temperature hydrothermal plumes and vents (called "smokers") along some parts of the mid-oceanic volcanic rift systems. However, to date, no direct observation has been made of a deep submarine eruption In progress.

During an explosive submarine eruption in the shallow open ocean, enormous piles of debris are built up around the active volcanic vent. Ocean currents rework the debris in shallow water, while other debris slumps from the upper part of the cone and flows into deep water along the sea floor. Fine debris and ash in the eruptive plume are scattered over a wide area in airborne clouds. Coarse debris in the same eruptive plume rains into the sea and settles on the flanks of the cone. Pumice from the eruption floats on the water and drifts with the ocean currents over a large area.

Geysers, Fumaroles, and Hot Springs

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Geysers, fumaroles (also called *solfataras*), and hot springs are generally found in regions of young volcanic activity. Surface water percolates downward through the rocks below the Earth's surface to high-temperature regions surrounding a magma reservoir, either active or recently solidified but still hot. There the water is heated, becomes less dense, and rises back to the surface along fissures and cracks. Sometimes these features are called "dying volcanoes" because they seem to represent the last stage of volcanic activity as the magma, at depth, cools and hardens.

Erupting geysers provide spectacular displays of underground energy suddenly unleashed, but their mechanisms are not completely understood. Large amounts of hot water are presumed to fill underground cavities. The water, upon further heating, is violently ejected when a portion of it suddenly flashes into steam. This cycle can be repeated with remarkable regularity, as for example, at Old Faithful Geyser in Yellowstone National Park, which erupts on an average of about once every 65 minutes.

Fumaroles, which emit mixtures of steam and other gases, are fed by conduits that pass through the water table before reaching the surface of the ground. Hydrogen sulfide (H2S), one of the typical gases issuing from fumaroles, readily oxidizes to sulfuric acid and native sulfur. This accounts for the intense chemical activity and brightly colored rocks in many thermal areas.

Hot springs occur in many thermal areas where the surface of the Earth intersects the water table. The temperature and rate of discharge of hot springs depend on factors such as the rate at which water circulates through the system of underground channelways, the amount of heat supplied at depth, and the extent of dilution of the heated water by cool ground water near the surface.

Volcano Environments

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There are more than 500 active volcanoes (those that have erupted at least once within recorded history) in the world--50 of which are in the United States (Hawaii, Alaska, Washington, Oregon, and California)--although many more are hidden under the seas. Most active volcanoes are strung like beads along, or near, the margins of the continents, and more than half en circle the Pacific Ocean as a "Ring of Fire."

Many volcanoes are in and around the Mediterranean Sea. Mount Etna in Sicily is the largest and hiqhest of these mountains. Italy's Vesuvius is the only active volcano on the European mainland. Near the island of Vulcano, the volcano Stromboli has been in a state of nearly continuous, mild eruption since early Roman times. At night, sailors in the Mediterranean can see the glow from the fiery molten material that is hurled into the air. Very appropriately, Stromboli has been called "the lighthouse of the Mediterranean.

Some volcanoes crown island areas lying near the continents, and others form chains of islands in the deep ocean basins. Volcanoes tend to cluster along narrow mountainous belts where folding and fracturing of the rocks provide channelways to the surface for the escape of magma. Significantly, major earthquakes also occur along these belts, indicating that volcanism and seismic activity are often closely related, responding to the same dynamic Earth forces.

In a typical "island-arc" environment, volcanoes lie along the crest of an arcuate, crustal ridge bounded on its convex side by a deep oceanic trench. The granite or granitelike layer of the continental crust extends beneath the ridge to the vicinity of the trench. Basaltic magmas, generated in the mantle beneath the ridge, rise along fractures through the granitic layer. These magmas commonly will be modified or changed in composition during passage through the granitic layer and erupt on the surface to form volcanoes built largely of nonbasaltic rocks.

In a typical "oceanic" environment, volcanoes are alined along the crest of a broad ridge that marks an active fracture system in the oceanic crust. Basaltic magmas, generated in the upper mantle beneath the ridge, rise along fractures through the basaltic layer. Because the granitic crustal layer is absent, the magmas are not appreciably modified or changed in composition and they erupt on the surface to form basaltic volcanoes.

In the typical "continental" environment, volcanoes are located unstable, mountainous belts that have thick roots of granite or granitelike rock. Magmas, generated near the base of the mountain root, rise slowly or intermittently along fractures in the crust. During passage through the granitic layer, magmas are commonly modified or changed in composition and erupt on the surface to form volcanoes constructed of nonbasaltic rocks.

Plate-Tectonics Theory

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According to the now generally accepted "plate-tectonics" theory, scientists believe that the Earth's surface is broken into a number of shifting slabs or plates, which average about 50 miles in thickness. These plates move relative to one another above a hotter, deeper, more mobile zone at average rates as great as a few inches per year. Most of the world's active volcanoes are located along or near the boundaries between shifting plates and are called "plate-boundary" volcanoes. However, some active volcanoes are not associated with plate boundaries, and many of these so-called "intra-plate" volcanoes form roughly linear chains in the interior of some oceanic plates. The Hawaiian Islands provide perhaps the best example of an "intra-plate" volcanic chain, developed by the northwest-moving Pacific plate passing over an inferred "hot spot" that initiates the magma-generation and volcano formation process. The peripheral areas of the Pacific Ocean Basin, containing the boundaries of several plates, are dotted by many active volcanoes that form the so-called "Ring of Fire." The "Ring" provides excellent examples of "plate boundary" volcanoes, including Mount St. Helens.

The accompanying figure shows the boundaries of lithosphere plates that are presently active. The double lines indicate zones of spreading from which plates are moving apart. The lines with barbs show zones of underthrusting (subduction), where one plate is sliding beneath another. The barbs on the lines indicate the overriding plate. The single line defines a strike-slip fault along which plates are sliding horizontally past one another. The stippled areas indicate a part of a continent, exclusive of that along a plate boundary, which is undergoing active extensional, compressional, or strike-slip faulting.

Extraterrestrial Volcanism

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Volcanoes and volcanism are not restricted to the planet Earth. M \anned and unmanned planetary explorations, beginning in the late 1960's, have furnished graphic evidence of past volcanism and its products on the Moon, Mars, Venus and other planetary bodies. Many pounds of volcanic rocks were collected by astronauts during the various Apollo lunar landing missions. Only a small fraction of these samples have been subjected to exhaustive study by scientists. The bulk of the material is stored under controlled-environment conditions at NASA's Lunar Receiving Laboratory in Houston, Tex., for future study by scientists.

From the 1976-1979 Viking mission, scientists have been able to study the volcanoes on Mars, and their studies are very revealing when compared with those of volcanoes on Earth. For example, Martian and Hawaiian volcanoes closely resemble each other in form. Both are shield volcanoes, have gently sloping flanks, large multiple collapse pits at their centers, and appear to be built of fluid lavas that have left numerous flow features on their flanks. The most obvious difference between the two is size. The Martian shields are enormous. They can grow to over 17 miles in height and more than 350 miles across, in contrast to a maximum height of about 6 miles and width of 74 miles for the Hawaiian shields.

Voyager-2 spacecraft images taken of lo, a moon of Jupiter, captured volcanoes in the actual process of eruption. The volcanic plumes shown on the image rise some 60 to 100 miles above the surface of the moon. Thus, active volcanism is taking place, at present, on at least one planetary body in addition to our Earth.

Volcano Monitoring and Research

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It has been said that the science of "volcanology" originated with the accurate descriptions of the eruption of Vesuvius in A.D. 79 contained in two letters from Pliny the Younger to the Roman historian Tacitus. Pliny's letters also described the death of his uncle, Pliny the Elder, who was killed in the eruption. Actually, however, it was not until the 19th century that serious scientific inquiry into volcanic phenomena flourished as part of the general revolution in the physical and life sciences, including the new science of "geology." In 1847, an observatory was established on the flanks of Vesuvius, upslope from the site of Herculaneum, for the more or less continuous recording of the activity of the volcano that destroyed the city in A.D. 79. Still, through the first decade of the 20th century, the study of volcanoes by and large continued to be of an expeditionary nature, generally undertaken after the eruption had begun or the activity had ceased.

Perhaps "modern" volcanology began in 1912, when Thomas A. Jaggar, Head of the Geology Department of the Massachusetts Institute of Technology, founded the Hawaiian Volcano

Observatory (HVO), located on the rim of Kilauea's caldera. Initially supported by an association of Honolulu businessmen, HVO began to conduct systematic and continuous monitoring of seismic activity preceding, accompanying, and following eruptions, as well as a wide variety of other geological, geophysical, and geochemical observations and investigations. Between 1919 and 1948, HVO was administered by various Federal agencies (National Weather Service, U.S. Geological Survey, and National Park Service), and since 1948 it has been operated continuously by the Geological Survey as part of its Volcano Hazards Program. The more than 75 years of comprehensive investigations by HVO and other scientists in Hawaii have added substantially to our understanding of the eruptive mechanisms of Kilauea and Mauna Loa, two of the world's most active volcanoes. Moreover, the Hawaiian Volcano Observatory pioneered and refined most of the commonly used volcano-monitoring techniques presently employed by other observatories monitoring active volcanoes elsewhere, principally in Indonesia, Italy, Japan, Latin America, New Zealand, Lesser Antilles (Caribbean), Philippines, and Kamchatka (U .S.S.R.).

What does "volcano monitoring" actually involve? Basically, it is the keeping of a detailed "diary" of the changes--visible and invisible--in a volcano and its surroundings. Between eruptions, visible changes of importance to the scientists would include marked increase or decrease of steaming from known vents; emergence of new steaming areas; development of new ground cracks or widening of old ones; unusual or inexplicable withering of plant life; changes in the color of mineral deposits encrusting fumaroles; and any other directly observable, and often measurable, feature that might reflect a change in the state of the volcano. Of course, the "diary" keeping during eruptive activity presents additional tasks. Wherever and whenever they can do so safely, scientists document, in words and on film, the course of the eruption in detail; make temperature measurements of lava and gas; collect the eruptive products and gases for subsequent laboratory analysis; measure the heights of lava fountains or ash plumes; gage the flow rate of ash ejection or lava flows; and carry out other necessary observations and measurements to fully document and characterize the eruption. For each eruption, such documentation and data collection and analysis provide another building block in constructing a model of the characteristic behavior of a given volcano or type of eruption.

Volcano monitoring also involves the recording and analysis of volcanic phenomena not visible to the human eye, but measurable by precise and sophisticated instruments. These phenomena include ground movements, earthquakes (particularly those too small to be felt by people), variations in gas compositions, and deviations in local electrical and magnetic fields that respond to pressure and stresses caused by the subterranean magma movements.

Some common methods used to study invisible, volcano-related phenomena are based on:

1. Measurement of changes in the shape of the volcano-- volcanoes gradually swell or "inflate" in building up to an eruption because of the influx of magma into the volcano's reservoir or "plumbing system"; with the onset of eruption, pressure is immediately relieved and the volcano rapidly shrinks or "deflates." A wide variety of instruments, including precise spirit-levels, electronic "tiltmeters, and electronic-laser beam instruments, can measure changes in the slope or "tilt" of the volcano or in vertical and horizontal distances with a precision of only a few parts in a million.

2. Precise determination of the location and magnitude of earthquakes by a well-designed

seismic network--as the volcano inflates by the rise of magma, the enclosing rocks are deformed to the breaking point to accommodate magma movement. When the rock ultimately fails to permit continued magma ascent, earthquakes result. By carefully mapping out the variations with time in the locations and depths of earthquake foci, scientists in effect can track the subsurface movement of magma, horizontally and vertically.

3. Measurement of changes in volcanic-gas composition and in magnetic field--the rise of magma high into the volcanic edifice may allow some of the associated gases to escape along fractures, thereby causing the composition of the gases (measured at the surface) to differ from that usually measured when the volcano is quiescent and the magma is too deep to allow gas to escape. Changes in the Earth's magnetic field have been noted preceding and accompanying some eruptions, and such changes are believed to reflect temperature effects and/or the content of magnetic minerals in the magma.

Recording historic eruptions and modern volcano-monitoring in themselves are insufficient to fully determine the characteristic behavior of a volcano, because a time record of such information, though perhaps long in human terms, is much too short in geologic terms to permit reliable predictions of possible future behavior. A comprehensive investigation of any volcano must also include the careful, systematic mapping of the nature, volume, and distribution of the products of prehistoric eruptions, as well as the determination of their ages by modern isotopic and other dating methods. Research on the volcano's geologic past extends the data base for refined estimates of the recurrence intervals of active versus dormant periods in the history of the volcano. With such information in hand, scientists can construct so-called "volcanic hazards" maps that delineate the zones of greatest risk around the volcano and that designate which zones are particularly susceptible to certain types of volcanic hazards (lava flows, ash fall, toxic gases, mudflows and associated flooding, etc.).

A strikingly successful example of volcano research and volcanic hazard assessment was the 1978 publication (Bulletin 1383-C) by two Geological Survey scientists, Dwight Crandell and Donal Mullineaux, who concluded that Mount St. Helens was the Cascade volcano most frequently active in the past 4,500 years and the one most likely to reawaken to erupt, "...perhaps before the end of this century." Their prediction came true when Mount St. Helens rumbled back to life in March of 1980. Intermittent explosions of ash and steam and periodic formation of short-lived lava domes continued throughout the decade. Analysis of the volcano's past behavior indicates that this kind of eruptive activity may continue for years or decades, but another catastrophic eruption like that of May 18, 1980, is unlikely to occur soon.

On 18 May 1982, the U.S. Geological Survey (USGS) formally dedicated the David A. Johnston Cascades Volcano Observatory (CVO) in Vancouver, Washington, in memory of the Survey volcanologist killed two years earlier. This facility--a sister observatory to the Hawaiian Volcano Observatory-- facilitates the increased monitoring and research on not only Mount St. Helens but also the other volcanoes of the Cascade Range of the Pacific Northwest. More recently, in cooperation with the State of Alaska, the USGS established the Alaska Volcano Observatory in March 1988. The work being done at these volcano observatories provides important comparisons and contrasts between the behavior of the generally non-explosive Hawaiian shield volcanoes and that of the generally explosive composite volcanoes of the Cascade and Alaskan Peninsula-Aleutian chains.

Volcanoes and People

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Volcanoes both harass and help mankind. As dramatically demonstrated by the catastrophic eruption of Mount St. Helens on May 1980 and of Pinatubo in June 1991, volcanoes can wreak havoc and devastation in the short term. The types of volcanic and associated hazards are not described in this booklet but treated in several of the publications listed in **Suggested Reading**. However, it should be emphasized that the short-term hazards posed by volcanoes are balanced by benefits of volcanism and related processes over geologic time. Volcanic materials ultimately break down to form some of the most fertile soils on Earth, cultivation of which fostered and sustained civilizations. People use volcanic products as construction materials, as abrasive and cleaning agents, and as raw materials for many chemical and industrial uses. The internal heat associated with some young volcanic systems has been harnessed to produce geothermal energy. For example, the electrical energy generated from The Geysers geothermal field in northern California can meet the present power consumption of the city of San Francisco.

The challenge to scientists involved with volcano research is to mitigate the short-term adverse impacts of eruptions, so that society may continue to enjoy the long-term benefits of volcanism. They must continue to improve the capability for predicting eruptions and to provide decision makers and the general public with the best possible information on high-risk volcanoes for sound decisions on land-use planning and public safety. Geoscientists still do not fully understand how volcanoes really work, but considerable advances have been made in recent decades. An improved understanding of volcanic phenomena provides important clues to the Earth's past, present, and possibly its future.

Suggested Reading

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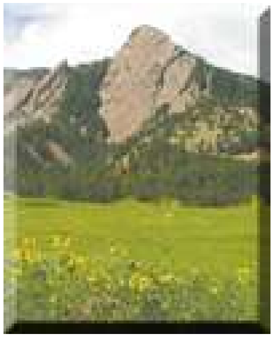
General Information Products [Online]



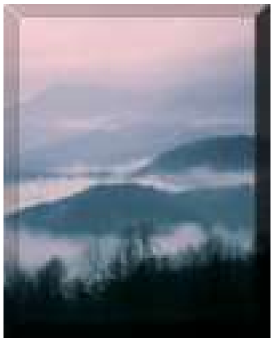
GIP 2A-E. Ride the Rockies
http://pubs.usgs.gov/gip/2004/02/

Geology highlights along the Ride The Rockies 2004 route.

General-Interest Publications [Online]

Acid Rain and Our Nation's Capital
http://pubs.usgs.gov/gip/acidrain/

This booklet focuses on acid rain and its impact on our Nation's capital. Rain in Washington, D.C., has an average acidity of 4.2, about as acid as a carbonated drink and more than ten times as acid as clean, unpolluted rain. This booklet will define acid rain, explain what effects it has on marble and limestone buildings, and show, on a walking tour, some of the places in our Nation's capital where you can see the impact of acid precipitation.



Birth of the Mountains: The Geologic Story of the Southern Appalachian Mountains
http://pubs.usgs.gov/gip/birth/

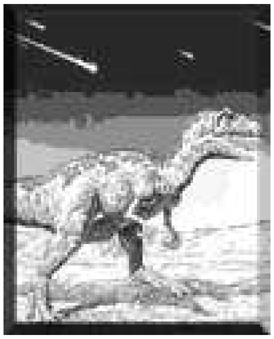
The Southern Appalachian Mountain region is known worldwide for its great beauty and biological diversity. Why does this area have such beautiful scenery and such a diversity of plants and animals? How do the mountains, and the rocks and minerals of which they are made, affect the lives of people? How do people affect the mountains? To address these questions, we need to understand what took place millions of years ago and how these geologic events have influenced the landscape, climate, soils, and living things we see today.

Building Stones of Our Nation's Capital
http://pubs.usgs.gov/gip/stones/

The buildings of our Nation's Capital have been constructed with rocks from quarries throughout the United States and many distant lands. Each building shows important features of various stones and the geologic environment in which they were formed. This booklet describes the source and appearance of many of the stones used in building Washington, D.C. A map and a walking tour guide are included to help you discover Washington's building stones on your own.

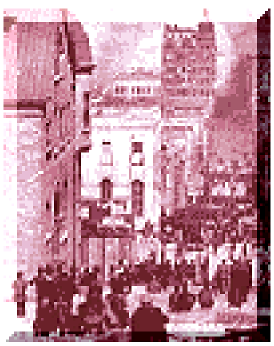
Deserts: Geology and Resources
http://pubs.usgs.gov/gip/deserts/

Approximately one-third of the Earth's land surface is desert, arid land with meager rainfall that supports only sparse vegetation and a limited population of people and animals. Deserts--stark, sometimes mysterious worlds--have been portrayed as fascinating environments of adventure and exploration from narratives such as that of Lawrence of Arabia to movies such as "Dune."



Dinosaurs: Facts and Fiction
http://pubs.usgs.gov/gip/dinosaurs/

Few subjects in the Earth sciences are as fascinating to the public as dinosaurs. The study of dinosaurs stretches our imaginations, gives us new perspectives on time and space, and invites us to discover worlds very different from our modern Earth.



Earthquakes
http://pubs.usgs.gov/gip/earthq1/

One of the most frightening and destructive phenomena of nature is a severe earthquake and its terrible aftereffects. If the earthquake occurs in a populated area, it may cause many deaths and injuries and extensive property damage. Today we are challenging the assumption that earthquakes must present an uncontrollable and unpredictable hazard to life and property. Scientists have begun to estimate the locations and likelihoods of future damaging earthquakes. Sites of greatest hazard are being identified, and definite progress is being made in designing structures that will withstand the effects of earthquakes.

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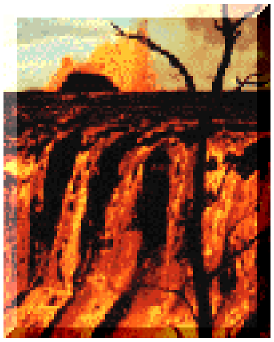
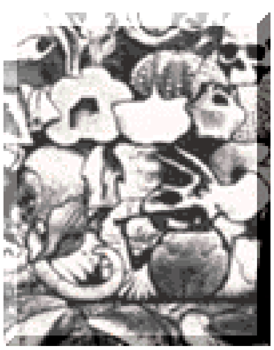


[Eruptions of Hawaiian Volcanoes: Past, Present, and Future](http://pubs.usgs.gov/gip/hawaii/)
http://pubs.usgs.gov/gip/hawaii/

Viewing an erupting volcano is a memorable experience, one that has inspired fear, superstition, worship, curiosity, and fascination throughout the history of mankind. In modern times, volcanic phenomena have attracted intense scientific interest, because they provide the key to understanding processes that have created and shaped more than 80 percent of the Earth's surface. The active Hawaiian volcanoes have received special attention worldwide because of their frequent spectacular eruptions, which can be viewed and studied with relative ease and safety.

[Eruptions of Mount St. Helens: Past, Present, and Future](http://pubs.usgs.gov/publications/msh/)
http://pubs.usgs.gov/publications/msh/

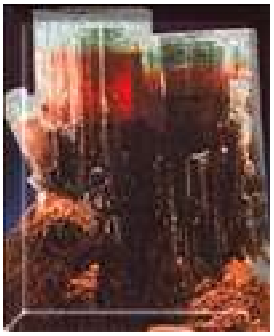
May 18, 1980. On that fateful day, Mount St. Helens Volcano in Washington exploded violently after 2 months of intense earthquake activity and intermittent, relatively weak eruptions, causing the worst volcanic disaster in the recorded history of the United States. The cataclysmic eruption and related events on May 18 rank among the most significant geologic events in the United States during the 20th century.



Fossils, Rocks, and Time

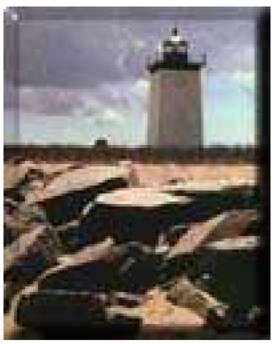
http://pubs.usgs.gov/gip/fossils/

Fossils are the recognizable remains of past life on Earth and are fundamental to the geologic time scale. To tell the age of most layered rocks, scientists study the fossils these rocks contain. Fossils provide important evidence to help determine what happened in Earth history and when it happened.



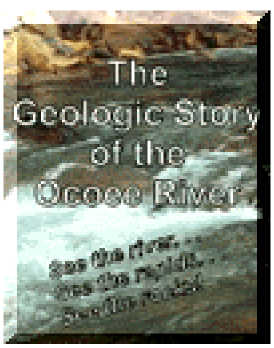
Gemstones
http://minerals.usgs.gov/minerals/pubs/commodity/gemstones/sp14-95/

An overview of the production of specific U.S. gemstones



The Geologic History of Cape Cod, Massachusetts
http://pubs.usgs.gov/gip/capecod/

Cape Cod, a sandy peninsula built mostly during the ice age, juts into the Atlantic Ocean like a crooked arm. Geologists are interested in Cape Cod because it was formed, by glaciers, very recently in terms of geologic time and because the shore is ever changing as the Cape adjusts to the rising sea.



The Geologic Story of the Ocoee River

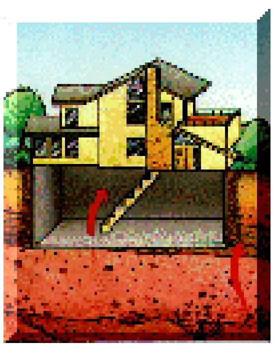
http://pubs.usgs.gov/gip/ocoee2/

Over millions of years, the Ocoee River has cut a steep, winding channel into a mountainside of hard rock. As you travel through the Ocoee River Gorge along US Highway 64 in the scenic Cherokee National Forest of southeastern Tennessee, take some time to look at the rocks along the way.

Companion brochure: Geology of the Ocoee Whitewater Center, Cherokee National Forest
http://pubs.usgs.gov/gip/ocoee/

Geologic Time
http://pubs.usgs.gov/gip/geotime/

The Earth is very old -- 4.5 billion years or more -- according to recent estimates. This vast span of time, called geologic time by earth scientists, is difficult to comprehend in the familiar time units of months and years, or even centuries. How then do scientists reckon geologic time, and why do they believe the Earth is so old? A great part of the secret of the Earth's age is locked up in its rocks, and our centuries-old search for the key led to the beginning and nourished the growth of geologic science.

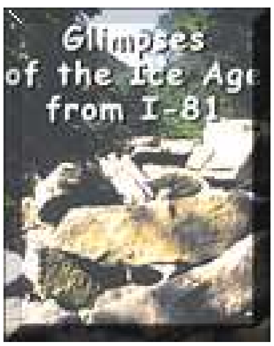


The Geology of Radon
http://energy.cr.usgs.gov/radon/georadon.html

High levels of indoor radon are found in every state. We know from medical and environmental studies that radon can be a health risk, primarily as a cause of lung cancer. Radon comes from the soil, rock, and water around us. Because levels of radon vary from place to place, and because houses differ in their vulnerability to radon, it is important that all homes be measured for radon. These pages present important geological information about radon; how it forms, the kinds of rocks and soils it comes from, and how it moves through the ground or is carried by water into buildings, and explains the way geologists estimate the radon potential of an area.

Glaciers: Clues to Future Climate
http://pubs.usgs.gov/gip/glaciers/

A glacier is a large mass of ice having its genesis on land and represents a multiyear surplus of snowfall over snowmelt. At the present time, perennial ice covers about 10 percent of the land areas of the Earth. Although glaciers are generally thought of as polar entities, they also are found in mountainous areas throughout the world, on all continents except Australia, and even at or near the Equator on high mountains in Africa and South America.



Glimpses of the Ice Age from I-81
http://pubs.usgs.gov/gip/i81/

Travelers on Interstate Highway 81 can see remnants of the Ice Age on the mountains between Strasburg and Harrisonburg, Virginia. Scattered along the miles of green, forested mountains are many gray patches without any forests. These treeless patches, or openings, in the steep mountain forests are block fields -- geologic features that owe their origin to the Ice Age.

Gold
http://pubs.usgs.gov/gip/gold/

Through the ages, men and women have cherished gold, and many have had a compelling desire to amass great quantities of it -- so compelling a desire, in fact, that the frantic need to seek and hoard gold has been aptly named "gold fever." Gold was among the first metals to be mined because it commonly occurs in its native form -- that is, not combined with other elements -- because it is beautiful and imperishable, and because exquisite objects can be made from it.

TEXT ONLY [NO GRAPHICS]
http://pubs.usgs.gov/gip/prospect1/goldgip.html

The Great Ice Age
http://pubs.usgs.gov/gip/ice_age/

The Great Ice Age, a recent chapter in the Earth's history, was a period of recurring widespread glaciations. Mountain glaciers formed on all continents, the icecaps of Antarctica and Greenland were more extensive and thicker than today, and vast glaciers, in places as much as several thousand feet thick, spread across North America and Eurasia.

The Interior of the Earth
http://pubs.usgs.gov/gip/interior/

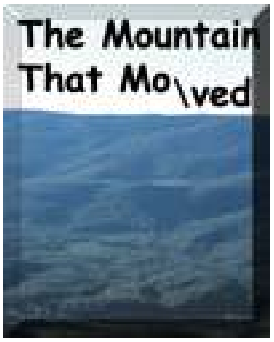
Three centuries ago, Sir Isaac Newton determined that the average density of the Earth is twice that of surface rocks and that the Earth's interior therefore must be composed of much denser material. Our knowledge of what's inside the Earth has improved immensely since Newton's time, but his estimate of the density remains essentially unchanged. This brochure presents current information on what makes up the interior of our planet.

[Man Against Volcano: The Eruption on Heimaey, Vestmannaeyjar, Iceland](http://pubs.usgs.gov/gip/heimaey/)
http://pubs.usgs.gov/gip/heimaey/

One of the most destructive volcanic eruptions in the history of Iceland began in the early morning of January 23,1973, near the country's premier fishing port, the town of Vestmannaeyjar, on Heimaey, the only inhabited isle in the Vestmannaeyjar volcanic archipelago. This booklet discusses the impact of the 1973 volcanic eruption of Eldfell on the island of Heimaey. Before the eruption was over, approximately one-third of the town of Vestmannaeyjer had been obliterated, but, more importantly, the potential damage probably was reduced by the spraying of seawater onto the advancing lava f!ows, causing them to be slowed, stopped, or diverted from the undamaged portion of the town.

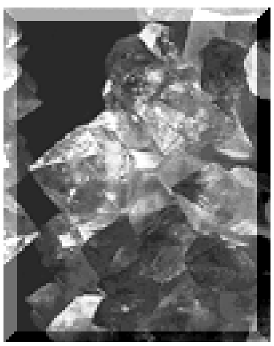
Monitoring Active Volcanoes
http://pubs.usgs.gov/gip/monitor/

Centuries ago, the Romans attributed volcanic and related phenomena (including earthquakes) mainly to the movement of wind imprisoned inside the Earth rushing violently to the surface. Today, scientists know that volcanic eruptions occur when buoyant magma (molten rock) that formed deep in the Earth ascends to the surface and ultimately is ejected upon release of gas pressure. With precise instruments and refined data analysis, it is now possible to track the subsurface movements of magma by monitoring the earthquakes and measuring the ground changes that accompany such movements.



[The Mountain That Moved
http://pubs.usgs.gov/gip/mountain/](http://pubs.usgs.gov/gip/mountain/)

Prehistoric, giant landslides in Montgomery and Craig Counties, Va., in the Blacksburg/Wythe Ranger Districts of the Jefferson National Forest, are the largest known landslides in eastern North America and are among the largest in the world. One of the landslides is more than 3 miles long! The ancient, giant landslides extend for more than 20 miles along the eastern slope of Sinking Creek Mountain. Enormous slabs of rock ranging from about 0.2 to more than 1.5 square miles in size broke loose and slid downslope under the influence of gravity. The movement of some slides may have been slow, but the movement of others was probably sudden and catastrophic.



[Natural Gemstones
http://pubs.usgs.gov/gip/gemstones/](http://pubs.usgs.gov/gip/gemstones/)

A natural gemstone is a mineral, stone, or organic matter that can be cut and polished or otherwise treated for use as jewelry or other ornament. A precious gemstone has beauty, durability, and rarity, whereas a semiprecious gemstone has only one or two of these qualities. A gem is a gemstone that has been cut and polished.

Our Changing Continents

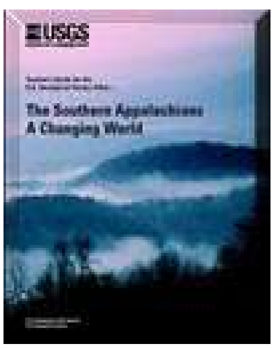
http://pubs.usgs.gov/gip/continents/

Where were the land areas and oceans of the North American Continent 1 million years ago, compared to their present locations? Was North America always about the same size and shape that it is today? To answer these questions, geologists must interpret the clues they find preserved in the rocks.

The San Andreas Fault
http://pubs.usgs.gov/gip/earthq3/

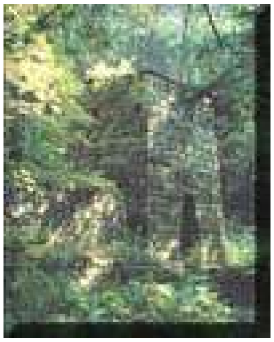
Scientists have learned that the Earth's crust is fractured into a series of "plates" that have been moving very slowly over the Earth's surface for millions of years. Two of these moving plates meet in western California; the boundary between them is the San Andreas fault.

TEXT ONLY [NO GRAPHICS]
http://pubs.usgs.gov/gip/earthq3/safaultgip.html



***The Southern Appalachians: A Changing World* Teacher's Guide**
http://pubs.usgs.gov/gip/so_app/

The video *The Southern Appalachians: A Changing World* describes the Southern Appalachian Mountains and how the geologic events that took place millions of years ago influenced the landscape, climate, soils, and living things that can be seen there today. Spanning a vast area from Virginia to Georgia, the Southern Appalachians are some of the oldest mountains on Earth. Molded and shaped over eons by volcanism, erosion, glaciation, and other geologic forces, these mountains are known worldwide for their unusual beauty and rich biological diversity. This teacher's guide summarizes the video and includes 17 suggested activities and discussion topics to enhance viewing.



Silent Reminders
http://pubs.usgs.gov/gip/silent/

The iron industry played a vital role in the industrialization of the United States and in the development of the U.S. economy and society. Much of the early history of the iron industry took place in Virginia. The remains of 11 iron furnaces and nearby mines in the George Washington and Jefferson National Forests in Virginia and West Virginia are silent reminders of a time when iron mines and furnaces operated along a belt that extended through the Appalachian Mountains from New York State to Alabama.

The Severity of an Earthquake
http://pubs.usgs.gov/gip/earthq4/severitygip.html

Earthquakes are the result of forces deep within the Earth's interior that continuously affect the surface of the Earth. The energy from these forces is stored in a variety of ways within the rocks. When this energy is released suddenly, for example by shearing movements along faults in the crust of the Earth, an earthquake results. The severity of an earthquake can be expressed in terms of both intensity and magnitude. However, the two terms are quite different, and they are often confused.

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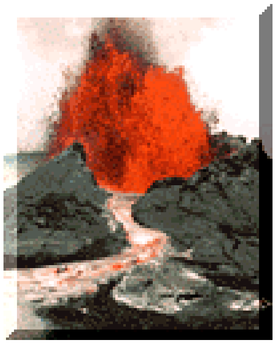
http://pubs.usgs.gov/gip/earthq4/severity_text.html



Volcanic and Seismic Hazards on the Island of Hawaii
http://pubs.usgs.gov/gip/hazards/

The eruptions of volcanoes often have direct, dramatic effects on the lives of people and on their property. People who live on or near active volcanoes can benefit greatly from clear, scientific information about the volcanic and seismic hazards of the area. This booklet provides such information for the residents of Hawaii so they may effectively deal with the special geologic hazards of the island.

Volcanoes
http://pubs.usgs.gov/gip/volc/

This booklet presents a generalized summary of the nature, workings, products, and hazards of the common types of volcanoes around the world, along with a brief introduction to the techniques of volcano monitoring and research.

TEXT ONLY [NO GRAPHICS]
http://pubs.usgs.gov/gip/volc/text.html

Volcanoes of the United States

http://pubs.usgs.gov/gip/volcus/

The United States ranks third, behind Indonesia and Japan, in the number of historically active volcanoes (that is, those for which we have written accounts of eruptions). In addition, about 10 percent of the more than 1,500 volcanoes that have erupted in the past 10,000 years are located in the United States. Most of these volcanoes are found in the Aleutian Islands, the Alaska Peninsula, the Hawaiian Islands, and the Cascade Range of the Pacific Northwest; the remainder are widely distributed in the western part of the Nation. A few U.S. volcanoes have produced some of the largest and most dangerous types of eruptions in this century, while several others have threatened to erupt.

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http://pubs.usgs.gov/gip/volcus/ustext.html

TEXT-ONLY [NO GRAPHICS] GENERAL INTEREST PUBLICATIONS

Collecting Rocks
http://pubs.usgs.gov/gip/collect1/collectgip.html

The Earth is made of rock, from the tallest mountains to the floor of the deepest ocean. Thousands of different types of rocks and minerals have been found on Earth. By studying how rocks form and change, scientists have built a solid understanding of the Earth we live on and its long history.

Plain Geology
http://pubs.usgs.gov/gip/plain.html

More than 50 years ago former Director George Otis Smith recognized that scientific reports are often couched in words and phrases that are understandable only to other scientists, engineers, or technicians. His plea for "Plain Geology" was a classic, just as applicable now as it was in 1921. It is herewith reprinted to make it generally available.

Prospecting for Gold in the United States
http://pubs.usgs.gov/gip/prospect2/prospectgip.html

Anyone who pans for gold hopes to be rewarded by the glitter of colors in the fine material collected in the bottom of the pan. Although the exercise and outdoor activity experienced in prospecting are rewarding, there are few thrills comparable to finding gold. Even an assay report showing an appreciable content of gold in a sample obtained from a lode deposit is exciting. The would-be prospector hoping for financial gain, however, should carefully consider all the pertinent facts before deciding on a prospecting venture.

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Monitoring Active Volcanoes

By Robert I. Tilling

Lava fountains, approximately 100 meters high, play at the vent during the September 1977 eruption of Kilauea Volcano. New lava flows and downed trees in foreground. (Photo by Boone Morrison.)

COVER PHOTOGRAPH: Scientist measures 350-meter-high fountain during March 1983 eruption at Kilauea Volcano, Hawaii.

Geologist records data at Redoubt Volcano, Alaska, while operating a Correlation Spectrometer (COSPEC), to measure the amount of sulfur dioxide in volcanic plumes.

This on-line edition contains the text from the original book in its entirety. Some figures have been modified to enhance legibility at screen resolutions.

The printed version of this publication is one of a series of general interest publications prepared by the U.S. Geological Survey to provide information about the earth sciences, natural resources, and the environment. To obtain a catalog of additional titles in the series *General Interest Publications of the U.S. Geological Survey*, contact:

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Maintained by Kathie Watson
Last updated 4.30.99

The Learning Web

Volcanoes!: Introduction

(For grades 4-8)

*This packet is only available online.

Volcanic eruptions are among the Earth's most powerful and destructive forces. Imagine hearing a volcano erupt thousands of miles away. Imagine looking through binoculars and seeing the top of a mountain collapse. Imagine discovering an ancient Roman city that had been buried in volcanic ash.

Volcanoes are also creative forces. The Earth's first oceans and atmosphere formed from the gases given off by volcanoes. In turn, oceans and an atmosphere created the environment that made life possible on our planet. Volcanoes have also shaped the Earth's landscape. Many of our mountains, islands, and plains have been built by volcanic eruptions. (View Poster Figure 1)

Why Do Volcanoes Erupt?

Deep within the Earth it is so hot that some rocks slowly melt and become a thick flowing substance called **magma**. Because it is lighter than the solid rock around it, magma rises and collects in magma chambers. Eventually some of the magma pushes through **vents** and **fissures** in the Earth's surface. A volcanic eruption occurs! Magma that has erupted is called **lava**.

Some volcanic eruptions are explosive and others are not. How explosive an eruption is depends on how runny or sticky the magma is. If magma is thin and runny, gases can escape easily from it. When this type of magma erupts, it flows out of the volcano. Lava flows rarely kill people, because they move slowly enough for people to get out of

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their way. Lava flows, however, can cause considerable destruction to buildings in their path.

If magma is thick and sticky, gases cannot escape easily. Pressure builds up until the gases escape violently and explode. In this type of eruption, the magma blasts into the air and breaks apart into pieces called **tephra**. Tephra can range in size from tiny particles of **ash** to house-size boulders.

Explosive volcanic eruptions can be dangerous and deadly. They can blast out clouds of hot tephra from the side or top of a volcano. These fiery clouds race down mountainsides destroying almost everything in their path. Ash erupted into the sky falls back to Earth like powdery snow, but snow that won't melt. If thick enough, blankets of ash can suffocate plants, animals, and humans. When hot volcanic materials mix with water from streams or melted snow and ice, mudflows form. Mudflows have buried entire communities located near erupting volcanoes.

Because there may be hundreds or thousands of years between volcanic eruptions, people may not be aware of a volcano's dangers. When Mount St. Helens in the State of Washington erupted in 1980, it had not erupted for 123 years. Most people thought Mount St. Helens was a beautiful, peaceful mountain and not a dangerous volcano.

Where Do Volcanoes Erupt?

Volcanoes occur because the Earth's **crust** is broken into plates that resemble a jigsaw puzzle. There are 16 major plates. These rigid plates float on a softer layer of rock in the Earth's **mantle**. As the plates move about they push together or pull apart. Most volcanoes occur near the edges of plates. (View Poster Figure 2)

When plates push together, one plate slides beneath the other. This is a **subduction zone**. When the plunging plate gets deep enough inside the **mantle**, some of the rock on the overlying plate melts and forms magma that can move upward and erupt at the Earth's surface. At **rift zones**, plates are moving apart and magma comes to the surface and erupts. Some volcanoes occur in the middle of plates at areas called **hotspots** - places where magma melts through the plate and erupts.

Why Do Volcanoes Grow?

Volcanoes grow because of repeated eruptions. There are three main kinds, or shapes, of volcanoes based on the type of materials they erupt.

Stratovolcanoes build from eruptions of lava and tephra that pile up in layers, or strata, much like layers of cake and frosting. These volcanoes form symmetrical cones with steep sides. (View Poster Figure 3)

Cinder cones build from erupting lava that breaks into small pieces as it blasts into the air. As the lava pieces fall back to the ground, they cool and harden into cinders that pile up around the volcano's vent. Cinder cones are very small cone-shaped volcanoes. (View Poster Figure 4)

Shield volcanoes form from eruptions of flowing lava. The lava spreads out and builds up volcanoes with broad, gently sloping sides. The shape resembles a warrior's shield. (View Poster Figure 5)

Mount St. Helens!

On May 18, 1980, Mount St. Helens violently erupted. For 2 months the volcano showed signs that it was waking up from its 123-year sleep. Earthquakes beneath the mountain increased. Steam and ash erupted. And a "bulge" grew on the mountain's steep north side. All these warning signs signaled that magma was moving upward inside the volcano. (View Poster Figure 6, 7, 8, & 9)

The First 35 Seconds

On the morning of the eruption, Gary Rosenquist was camped about 36 kilometers (11 miles) from the summit of Mount St. Helens. Another camper was looking through binoculars and noticed that the upper right side of the volcano looked "fuzzy." He shouted that the "mountain was going." Rosenquist began taking photographs.

An earthquake that occurred beneath the volcano shook loose the "bulge" on the mountain's steep north side. Rock and ice slide down the mountain. Then the mountain exploded gases, magma, and water laterally out the side where the "bulge" had been. The explosion hurled hot rock and ash at hurricane speeds. Ash and steam erupted vertically from the volcano's crater and continued for 9 hours.

The Mountain Blows its Top

Volcanic eruptions alter the surface of the Earth's **lithosphere**, the hard, outermost shell of the Earth.

Many eruptions have built Mount St. Helens' beautiful cone shape. The May 18, 1980, eruption, however, dramatically changed the volcano's size and shape. It tore off the mountain's top and blasted a giant crater in its side.

Smaller eruptions have continued since 1980. Mostly occurring on the bottom of the volcano's crater, each eruption squeezes up thick, pasty lava and sometimes spews out tephra. In photograph number 11, look for the dome that has formed inside the crater. Slowly, the volcano is rebuilding itself into its former shape.

(View Poster Figure 10 and Poster Figure 11)

Up in the Air

Volcanoes erupt materials into the **atmosphere**, the gases and water vapor that surround the Earth.

The eruption blasted ash and gases into the atmosphere. Winds carried ash great distances. The ash-covered truck shown here (Link to Poster Figure 12) was parked 19 kilometers (12 miles) from Mount St. Helens. Two men who were camped nearby died, suffocating from hot volcanic ash. They were two of 57 known fatalities.

In Yakima, a city in eastern Washington, ash began to fall about an hour after the eruption. It became so dark that lights were turned on all day. (View Poster Figure 13.) Face masks were necessary when people went outside. (View Poster Figure 14)It took 10 weeks to haul away the ash from Yakima's streets, sidewalks, and roofs.

Water, Rock, and Mud

The **hydrosphere** - the liquid water on and under the Earth's surface - can make volcanic eruptions more dangerous.

Before the May 18, 1980, eruption, the streams on Mount St. Helens were crystal clear. After the eruption, streams were choked with rock and mud. When water mixed with rock and mud, it created volcanic mudflows (also called lahars) that were able to move down the volcano's slopes. On the steepest slopes, the mudflows traveled up to 144 kilometers per hour (90 miles per hour). Some of the mudflows were as high as a six-storied building!

(View Poster Figure 15 and Poster Figure 16)

Fire and Ice

Ice and snow - the part of the Earth system called the **cryosphere** - can melt during a volcanic eruption.

Snow and ice-capped volcanoes like Mount St. Helens are especially dangerous if they erupt. Much of the water in Mount St. Helens' mudflows came from snow and ice melted by the heat of the eruption. These mudflows were as thick as wet cement and able to carry along almost anything that they picked up. Eyewitnesses reported seeing mudflows carry everything from farm animals to a fully loaded logging truck. Fortunately, when the mudlfow hit, no one was in the bus pictured here.

(View Poster Figure 17 and Poster Figure 18)

Death and Recovery

The Earth's **biosphere** - the realm of all living things - is affected during a volcanic eruption.

The force of the eruption on Mount St. Helens blew down giant trees like they were match sticks. Almost all of the animals that lived in these forests were killed as well. Birds were particularly hard hit. Some birds survived the eruption but died later because the insects and plants they ate had died.

Surprisingly, some plants and animals did survive. Plants sprouted from roots that survived even though the plants' tops had been sheared off. Animals such as gophers and ants survived in their underground homes. Within a few weeks of the eruption deer, elk, and other animals moved in from nearby areas to take advantage of the new plants that were sprouting.

(View Poster Figure 19 and Poster Figure 20)

Further Reading

- Make a Paper Volcano
- Eruptions of Mount St. Helens: Past, Present, and Future by Robert I. Tilling, Lyn Topinka, and Donald A. Swanson
- Monitoring Active Volcanoes by Robert Tilling
- Volcanoes by Robert Tilling
- Volcanoes of the United States by Steven Brantley

- Volcano Hazard Fact Sheets
- Volcano resources and references
- Volcano Hazards Program
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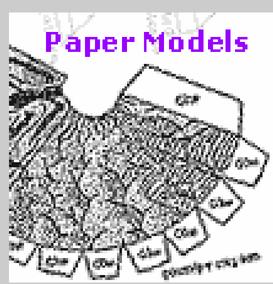

Make paper models volcanoes, earthquakes, fossils, and more.

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Lesson Plans and Activities

Changing World

The Earth is a time machine that has been changing throughout its 4.5 billion-year history. Tree rings, past climates, rocks, and caves all tell the story of change.

Working with Maps

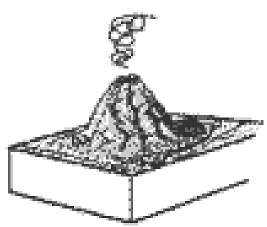
Maps of the Earth are illustrations of how we think of our planet. Throughout our history, explorers and scientists have tried to answer the questions "where are we?" and "Where are we going?"

Paper Models

Not unlike origami, paper models are fun to make, and provide three-dimensional views of earth events and phenomena. By printing out these models, cutting, pasting, and coloring, you'll soon have works of art--and science!

Go!

Volcanoes!



This model is intended to help students and others visualize a stratovolcano (inside and out) and to learn some of the terms used by geologists to describe it.

Educational Materials

As the Nation's largest water, earth, biological science, and civilian mapping agency, the U.S. Geological Survey (USGS) provides some of this science information as educational material. The product line includes a variety of teaching packets, booklets, posters, fact sheets, and CD-ROMs. Described below are products designed for K-12 teachers.

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Helping Your Child Learn Geography

This 32-page booklet, published in cooperation with the U.S. Department of Education and the National Geographic Society, is designed to help parents stir childrens curiosity about geography. The activities can also be used in the classroom.

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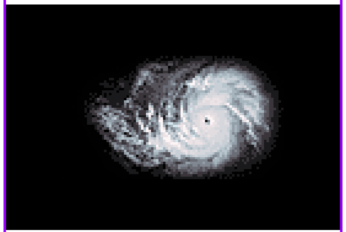

As a dynamic planet, the Earth has many hazards. Some of these hazards are from earthquakes and volcanic eruptions. Find out why the Earth is so restless.

Earthquake Effects

By studying the animation and the paper model, students will come to understand that earthquakes result from faulting in the Earth and that the potential consequences of earthquakes are numerous and serious.

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Grade level of class

Number of students

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- adequate
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2. The concepts presented were:

- too simple
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- too difficult (explain below in question 7)

3. This teaching packet:

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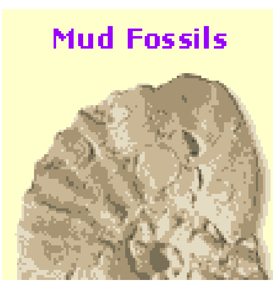
LIFE SCIENCE

Changing World Lessons		Grades
	Exploring Caves, an interdisciplinary set of materials for K-3, covers at least five scientific disciplines: earth science, hydrology, mapping, biology, and anthropology. This unit aims at helping teachers to sort and organize the most important ideas in this rich scientific area. *This packet is only available online.	K-3
	In Mud Fossils, K-3 students are invited to explore and observe real fossils and then make their own fossils using mud and found objects. *This packet is only available online.	K-3
	This packet is appropriate for grades 4-6. It covers four themes: time, change, natural cycles, and the Earth as home. Includes a two-sided color poster, teacher guide, and three activities. Each activity includes background material, an experiment, three lesson plans, and suggestions for further reading. *This packet is only available online.	4-6

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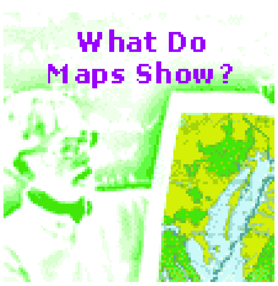
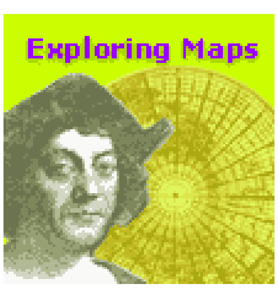
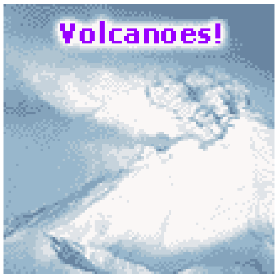
	Land and People: Finding a Balance is an environmental study project that engages high school students in studying ecosystems resource issues. The project focuses on the interaction between people and the environment in three regions on the United States: Cape Cod, Los Angeles, and the Everglades.	7-12
	In Geologic Age, students (grade 7-12) investigate radioactivity as a tool for measuring geologic time and how geologists use this information to determine the absolute age of rocks or minerals. *This packet is only available online.	7-12

GEOGRAPHY		
Working With Maps Lessons		**Grades**
	This teaching packet is appropriate for grades K-3. Students will learn basic concepts for visualizing objects from different perspectives and how to understand and use maps. The lessons center on a story about a little girl named Nikki who visits an imaginary amusement park. Nikki goes up in an unplanned balloon ride that gives her, and the students, different views of the park. *This packet is only available online.	K-3
	This teaching packet is for grades 5-8 and is organized around geographic themes: location, place, relationships, movement, and regions. A map is a picture of a place. Different maps show different information. No one map can show everything. Students will compare shaded relief maps, road maps, and topographic maps *This packet is only available online.	5-8
	Exploring Maps is an interdisciplinary set of materials on mapping for grades 7-12. Students will learn basic mapmaking and map-reading skills and will see how maps can answer fundamental geographic questions: "Where am I?" "What else is here?" "Where am I going?" *This packet is only available online.	7-12

EARTH SCIENCE

Earth Hazards Lessons		Grades
	In Volcanoes!, an interdisciplinary set of materials for grades 4-8, students will explore questions such as "What is a volcano?" "Where do volcanoes come from?" and "Can scientists forecast volcanic eruptions?" *This packet is only available online.	4-8
	Students will observe fault movements on a model of the earth's surface. *This packet is only available online.	7-12

Link to other online Lesson Plans

Lesson 6: Volcanoes and People

fig. 1

Mount Ranier

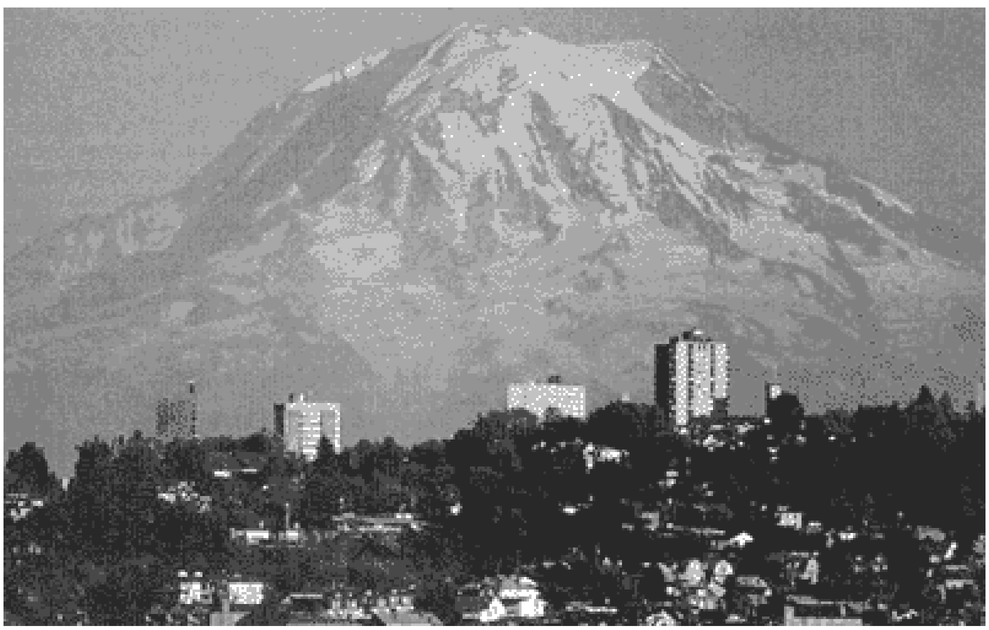


Fig 1: Snow-capped Mount Rainier rises behind Tacoma, Washington, Although Mount Rainier has not erupted in the past years, scientists consider it one of the most hazardous volcanoes in the Cascade Range.

Relative to other types of natural disasters, such as earthquakes, floods, hurricanes, and tornados, volcanic eruptions occur infrequently. Of the 1,500 active volcanoes on land, approximately 50-60 erupt each year. Approximately 1 million people have been killed by volcanic eruptions during the past 2,000 year.

- Activity 1
- Activity 2

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United States Has Many Active Volcanoes

Because many of the most hazardous volcanoes have not erupted during recent historic times, people erroneously consider them extinct. For Mount St. Helens, more than a century had elapsed since a major eruption; most people were not aware of its dangers. Mount St. Helens is one of more than 65 active or potentially active volcanoes in the continental United States, Alaska, and Hawaii. Only Indonesia and Japan have more!

Scientists of the U.S. Geological Survey continue to monitor Mount St. Helens and other volcanoes in the Cascade Range. They know from its past eruptive history that many of Mount St. Helens' eruptions have occurred in concentrated periods of time lasting decades or even centuries. For example, one eruptive phase began in 1480 and lasted for about 300 years. Based on that history, scientists anticipate that Mount St. Helens will continue to erupt episodically for decades to come before it returns to a dormant stage.

The eruption of Mount St. Helens served as a reminder that other dormant volcanoes can come to life again. Mount Shasta in Northern California, for example, probably last erupted in 1786. On a geological time scale, this very recent volcanic activity suggests that magma is still present beneath the volcano. On average, it has erupted once every 300 years over the past 3,500 years. The chance is 1 in 25 to 30 that it will erupt in any one decade and 1 in 3 or 4 within a person's lifetime.

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Forecasting Future Eruptions

Scientists have improved their ability to predict the time of a volcanic eruption, but estimating the size and style of an eruption remains a difficult challenge. Despite this challenge, scientists try to assess the potential consequences of a future eruption by reconstructing a volcano's history, which includes the pattern, magnitude, and frequency of its past eruptions. The principal means of developing this history is by mapping and dating the different types of volcanic materials that have been deposited by previous eruptions. Assembled into volcanic hazards maps, this information is vital for communities in volcanically active areas to use for land use and emergency preparedness planning. Knowing a volcano's past is crucial to forecasting its future behavior.

fig. 2

Cascade Eruptions

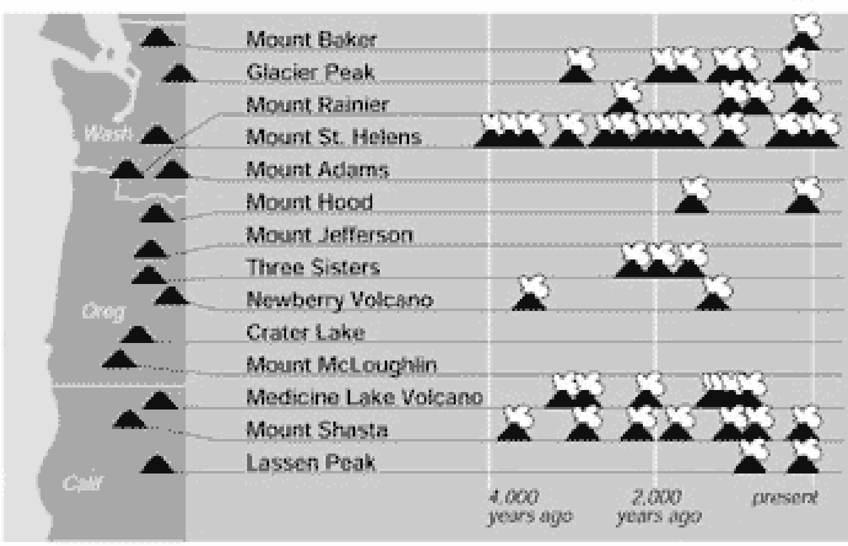

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Fig 2: Cascade Eruptions Chart. Eruptions in the Cascades have occurred at an average rate of one to two per century during the last 4,000 years. Four of those eruptions would have caused considerable damage and loss of life if they had occurred today without warning.

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Benefits Often Overlooked

Because of the destructive nature of a volcanic eruption, we tend to overlook a volcano's benefits. Magma circulates and deposits many valuable elements, such as gold, silver, zinc, sulfur, and copper. Magma heats ground water systems that can be tapped to produce geothermal power. This heated ground water can also result in geysers and hot springs. Volcanoes are also responsible for some of the world's most fertile soils. And volcanoes continuously bring materials from inside the Earth to the surface—recycling on a grand scale.

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Lesson 5: Death and Recovery

fig. 1

"This is It!"

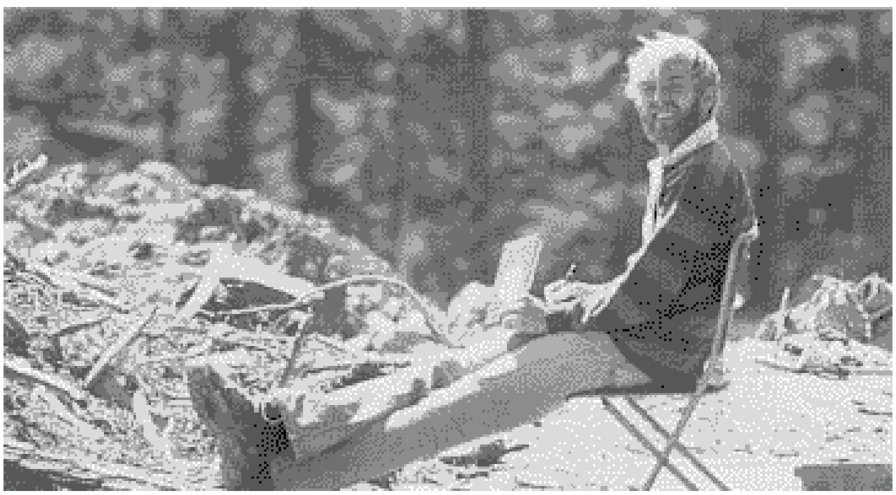

Fig 1: David A Johnston, USGS volcanologist, was monitoring Mount St. Helens on a ridge north of the volcano. At 8:30 a.m. on May 18, 1980, he made his last radio transmission: "Vancouver, Vancouver, this is it." No trace of him or his equipmenthas ever been found.

- Activity 1
- Activity 2

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The Impact on Plants

Devastation in the wake of the avalanche was equally dramatic, although a few individual plants did survive, sprouting from root fragments that had been swept along on the surface of the debris. Plant survival in the path of the mudflows was likewise sparse. In addition, ashfall, which blanketed the forest to the northeast, smothered small plants and retarded the growth of larger ones.

The force of the lateral blast from Mount St. Helens' north flank blew down or snapped off trees within a radius of 25 kilometers (15 miles) north of the eruption site. At a distance of 25 kilometers (15 miles) from the blast, the force was no longer powerful enough to mow down trees, but it remained hot enough to kill the trees in its path. Ironically, some of the trees killed were old-growth Douglas firs 200 to 500 years old, which had survived previous eruptions.

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The Impact on Animals

In the area affected by the blast, almost all wildlife vanished. Animals living above ground in the blast zone had no protection. Birds were particularly hard hit. Even those birds that survived the initial blast and avalanche died because the insects and plants they ate had perished. Insects were heavily affected, particularly by volcanic ash: the insects suffocated because ash clogged their body pores, or they dehydrated because glass-like ash abraded the cuticle that helps them retain moisture. Fewer than one-half of the small mammals species thought to have been living near Mount St. Helens were known to have survived. The death toll was nearly 7,000 large game animals, including deer, elk, and bear. The eruption severely damaged 26 lakes, killing an estimated 11 million fish, as well as incalculable numbers of fresh-water invertebrates. The loss of human lives was 57.

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Some Organisms Survived

The most surprising discovery following the eruption, however, was that many organisms survived in what appeared to be a lifeless gray landscape. In particular, plants sprouted in areas that had been protected under a snow cover and along stream banks and hillsides where erosion thinned ash deposits. Within a month, fireweed appeared from roots that had survived even though the tops of the plants were sheared off. Animals such as gophers and ants survived in their subterranean homes, while lake-dwelling frogs and salamanders escaped the blast under a protective cover of late winter ice.

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The Recovery

Three years after the eruption, biologists had identified the recovery of more than 90 percent of the preeruption species of plants. Many plants owed their lives to gophers. These burrowing animals acted like garden tillers, by bringing the existing soil to the surface and mixing it with nutrient-rich volcanic ash deposited by the May 18, 1980, eruption. As the gophers dug, they also brought seeds, bulbs, and root fragments up to the surface where they could begin to grow. The "tilled" soil was also far more likely to trap seeds blowing across its surface.

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Lesson 4: Fire, Rock, and Water

Mount St. Helens 2 years before its cataclysmic eruption. When the volcano exploded on May 18, 1980, huge volumes of snow and ice quickly melted and contributed to devastating floods and mudflows.

As hot volcanic debris melted snow and glacier ice on the upper slopes of Mount St. Helens, mudflows - fast-moving mixtures of volcanic debris and water - developed within minutes of the beginning of the May 18 eruption. By 10:10 a.m. Pacific Daylight Time, a **mudflow** had traveled 43 kilometers (27 miles) downstream in the South Fork Toutle River valley. And before the day ended, nearly all the streams that had their sources on Mount St. Helens were affected by mudflows.

Fortunately, the major mudflow took hours to reach populated areas, giving people time to evacuate. As a result, only a few deaths were attributable to mudflows. Volcanic mudflows are also called **lahars**, a term borrowed from Indonesia, where mudflows are a major volcanic hazard.

- Activity 1
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Mudflows' Destructive Force

The largest and most destructive mudflow came down the valley of the North Fork of the Toutle River. It originated from the hot debris from the avalanche, lateral blast, and ash falls that had been deposited in the upper part of the river valley during the first few minutes of the eruption. By afternoon, water from melting snow and glacial ice, and

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from within the debris itself began to flow. The mudflow steamed with hot volcanic materials (**pyroclastic debris**). Thick, like freshly mixed cement, the mudflow enveloped almost anything that it picked up along its path. Eyewitnesses reported seeing everything from ice chunks to a fully loaded logging truck in the flowing mixture. As debris, mud, and fallen trees choked the Toutle River, the river overflowed its banks and flooded, cresting at 6.4 meters (21 feet) above its normal stage.

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Snow and Ice Compound Dangers

Mudflows are particular hazards at snow-capped volcanoes such as Mount St. Helens. Even small eruptions of hot volcanic material can very quickly melt large volumes of snow and ice. The resulting surge of water erodes and mixes with volcanic rock to become mudflows. For example, the 1985 eruption of Nevada del Ruiz in Colombia was a very small eruption - ejecting only about 3 percent as much magma as Mount St. Helens - yet it generated high-volume mudflows because of the presence of snow and glacial ice on the volcano. The mudflows that swept down from Nevada del Ruiz buried the town of Armero, killing more than 23,000 people. Nevada del Ruiz, like Mount St. Helens, has snow and ice year round at its highest elevations.

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The Risk of Mudflows Continues

Even without a major eruption, mudflows and floods remain potential hazards of Mount St. Helens. As a result of the May 18, 1980, eruption, huge volumes of volcanic debris dammed preexisting streams. Because these dammed streams are composed of loose materials, they are structurally weak. If the dams fail, mudflows and floods can occur. Loose volcanic debris on steep slopes is also vulnerable to flowing during or after heavy rainfalls. The risk of mudflows and floods is greatest on Mount St. Helens during the winter months when precipitation is heaviest and the snowpack is thickest.

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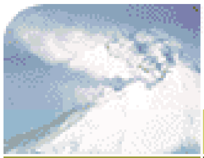

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Lesson 3: Up in the Air

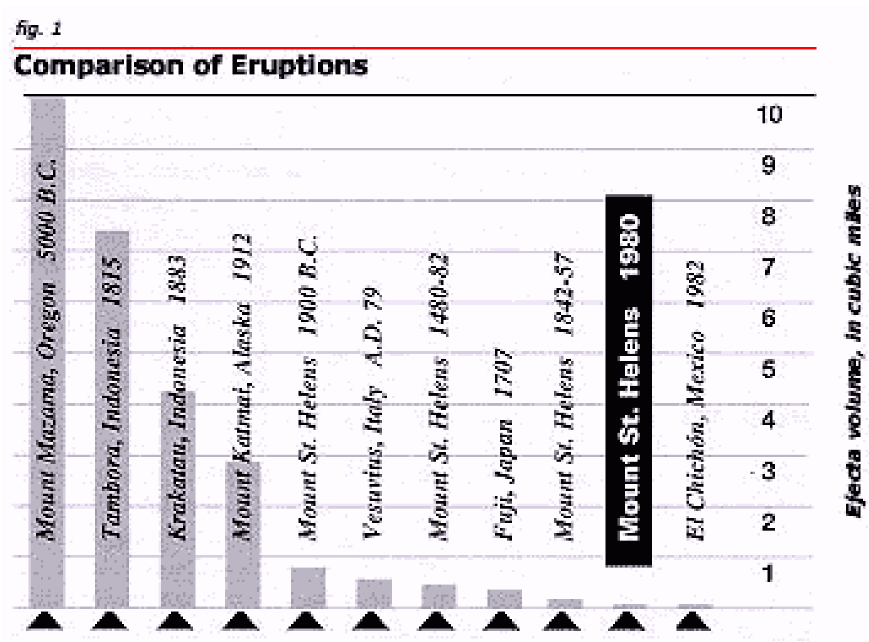

Fig 1: The volume of ash ejected during an eruption is one factor in measuring the size of an eruption. Note that the May 18 volume was less than several earlier eruptions of Mount St. Helens and considerably less than eruptions of other volcanoes.

In less than 10 minutes after the onset of the cataclysmic eruption of Mount St. Helens, a column of **tephra**, steam, **aerosols**, and gases reached an altitude of 19 kilometers (12 miles). Although the largest fragments of tephra fell back to the ground close to the volcano, the smallest fragments, ash and dust, were carried eastward by the **prevailing winds**. Five days after the eruption, monitoring instruments in New England detected ash from Mount St. Helens. Some of the ash eventually circled the globe and the smallest fragments and aerosols remained suspended for years in the **stratosphere**.

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Day Becomes Night

Moving at an average speed of 95 kilometers per hour (60 miles per hour), the ash cloud reached Yakima, Wash., by 9:45 a.m. Pacific Daylight Time and Spokane, Wash., about 2 hours later. In Yakima, a city of 51,000, day became night. Automobile and street lights remained on for the rest of the day as the eruption continued for more than 9 hours. Ash as fine as talcum powder clogged engine air filters and choked people - face masks or handkerchiefs were a necessity for those who ventured out of doors.

Ash blanketed the ground like snow, but snow that would not melt. Residents shoveled and bulldozed ash from streets, sidewalks, and roofs; an estimated 600,000 tons of ash were removed from the city. It took 10 weeks to haul it away!

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Volcanic Ash's Deadly Effects

Ash fall, however, is more than an inconvenience. It can be lethal to plants, wildlife, and humans. Swirling particles of ash in the atmosphere generated lightning, which in turn ignited hundreds of forest fires near the volcano. Autopsies revealed that most of the human deaths in the blast area resulted from asphyxiation, from inhaling hot volcanic ash during the first few minutes of the eruption.

As the ash settled to the ground, it also took its toll. Eastern Washington became known as the "ash belt" where many farm crops were destroyed in areas of thick accumulation. Volcanic ash can also affect aircraft operations. Jet engines are susceptible to damage: the volcanic ash coats and melts turbine blades, often causing the engines to stall.

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Impact on Climate

Volcanic eruptions can also affect climate and weather patterns. Mount St. Helens' 1980 eruptions did not have a significant effect on global climate, but the 1982 eruption of El Chichòn in Mexico, for example, had measurable effects. El Chichòn's magma was much richer in sulfur than Mount St. Helens'. As a result, the Mexican volcano produced sulfuric acid aerosols (a fine mist of particles) that formed a layer of haze in the stratosphere. This haze, which can remain in the atmosphere for years, reflects the sun's radiation and reduces surface temperatures. For example, more than a year after the April 1815 eruption of Indonesia's Tambora volcano, its effects were felt. In the northeastern United States, 1816 was so cold that snow fell in some New England States in June and July. It was known in New England as the "year without a summer."

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How Much Ash Fell?

In comparison to other historic eruptions, the volume of ash fall from the 1980 eruption of Mount St. Helens was relatively small (fig. 1). The eruption of Tambora ejected 150 times more ash than Mount St. Helens in 1980. And ash ejected by Mount Mazama (now Crater Lake), located about 125 kilometers (200 miles) south of Mount St. Helens, was even greater than Tambora. The 1980 eruption of Mount St. Helens was only an inkling of the destructive potential of a volcanic eruption.

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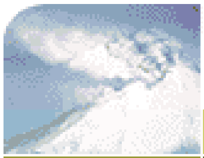

Lesson 2: Creators and Destroyers

On May 18, 1980, Mount St. Helens erupted violently. At 8:32 a.m. Pacific Daylight Time, a magnitude 5.1 earthquake occurred about a mile beneath the volcano, triggering a catastrophic series of events that transformed Mount St. Helens' picturesque mountain landscape into a gray wasteland.

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- Activity 2

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The Catastrophic Eruption

The earthquake shook the walls of the volcano's summit crater and triggered many small rock avalanches.Within seconds, a huge slab of the volcano's north flank began to slide, and small dark clouds billowed out of the base of the slide. Plumes of steam and ash also rose from the volcano's crater. As the avalanche of rock and ice raced down the mountain's north flank at more than 250 kilometers per hour (155 miles per hour), a massive explosion blasted out of the north side of the volcano. This **lateral blast** became a fearsome torrent of ash and rock that outraced the avalanche. Probably no more than 20 to 30 seconds had elapsed since the triggering earthquake!

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The Eruption Was No Surprise

The eruption of Mount St. Helens was not a surprise. For nearly 2 months, scientists had been monitoring changes at Mount St. Helens. For a volcano to erupt, magma must move to the Earth's surface. Increased earthquake activity, eruptions of steam and ash, and changes in the shape of the surface of the volcano all signal that magma is on the move toward the surface.

Inside the volcano, the solid rock that surrounds the molten rock often cracks from the increased pressure and causes earthquakes. Between March 20 and May 18, more than 10,000 earthquakes were recorded beneath Mount St. Helens. The largest of these were felt by people living near the volcano. In addition to recording the discrete jolts characteristic of earthquakes, **seismographs** also detected continuous rhythmic vibrations called **harmonic tremors**. These numerous small earthquakes were further evidence that magma was moving within the volcano.

As magma made room for itself inside the volcano's cone, the surface of the volcano swelled, or inflated. By early April, Mount St. Helens' north flank began to visibly bulge and crack. The bulge grew 2 to 3 meters (7 to 9 feet) a day and it moved outwards about 150 meters (450 feet) in 2 months.

When the 5.1 magnitude earthquake shook Mount St. Helens on May 18, 1980, the bulge collapsed. The resulting avalanche was the largest **volcanic avalanche** recorded in historical times. In turn, the sudden removal of masses of rock and ice by the avalanches triggered an explosive eruption of steam trapped in cracks and voids in the volcano and of gases dissolved in the magma. Unleashed by the abrupt release of pressure, magma, rock, ash, aerosols, and gases exploded from within the volcano's north flank.

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The Mountain is Transformed

In a few minutes, Mount St. Helens' symmetrical cone was transformed. It was 400 meters (1,312 feet) shorter and a gaping crater was gouged into its north side. An avalanche of rock, ash, ice, water, and fallen trees flowed as far as 9 kilometers (15 miles) down the valley of the North Fork Toutle River. Debris dumped into Spirit Lake raised the lakebed by more than 940 meters (295 feet). The lake's cool, crystal-clear waters became a black stew of rocks, mud, and floating trees. Gone were 70 percent of the **glaciers** that had crowned the volcano, melted by the heat of the eruption or carried away by the fast-moving avalanche. Towering forests with trees up to 45 meters (150 feet) were flattened and strewn like match sticks in the wake of the lateral blast and debris-laden avalanche.

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Eruptions Continue

Between May 18, 1980, and October 1995, Mount St. Helens has had at least 21 eruptions of magma and dozens of smaller gas explosions. All of the volcanic activity has taken place in the bottom of the crater created by the May 18, 1980, eruption. There Mount St. Helens is rebuilding itself. During each eruption, new lava squeezes up and pushes aside old material from the surface of the **dome**. The volcanic activity that began in 1980 is not yet over.

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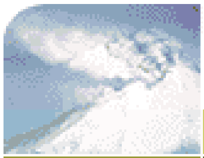

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VOLCANOES!

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Lesson 1: Windows Into the Earth

Until the spring of 1980, most people thought of Mount St. Helens as a serene, snow-capped mountain and not as a lethal **volcano**. The mountain had given little evidence that it posed a hazard for more than a century—long time in human terms but a blink of an eye in terms of the mountain's 50,000-year geologic history. A series of earthquakes that began in mid-March of 1980 sounded the alarm that Mount St. Helens was awakening from its sleep. In other words, Mount St. Helens, which had been **dormant**, became **active** and likely to erupt. Its catastrophic eruption 2 months later was a reminder that a fiery world lies beneath the Earth's surface.

- Activity 1
- Activity 2

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Why Volcanoes Occur

The roots of Mount St. Helen's are 110 to 330 kilometers (70 to 200 miles) below the Earth's surface. Here in the Earth's **mantle** (fig. 1) temperatures are hot enough to melt rock and form a thick, flowing substance called **magma**. Lighter than the solid rock that surrounds it, magma is buoyant much like a cork in water; being buoyant, it rises.

As the magma rises, some of it collects in large reservoirs, or magma chambers (poster fig.1) that fuel volcanoes. As the rising magma nears the Earth's surface, pressure decreases, which causes the gases in the magma to expand. This expansion propels the magma through openings in the Earth's surface: a volcanic eruption occurs. Once magma is erupted, it is called **lava**.

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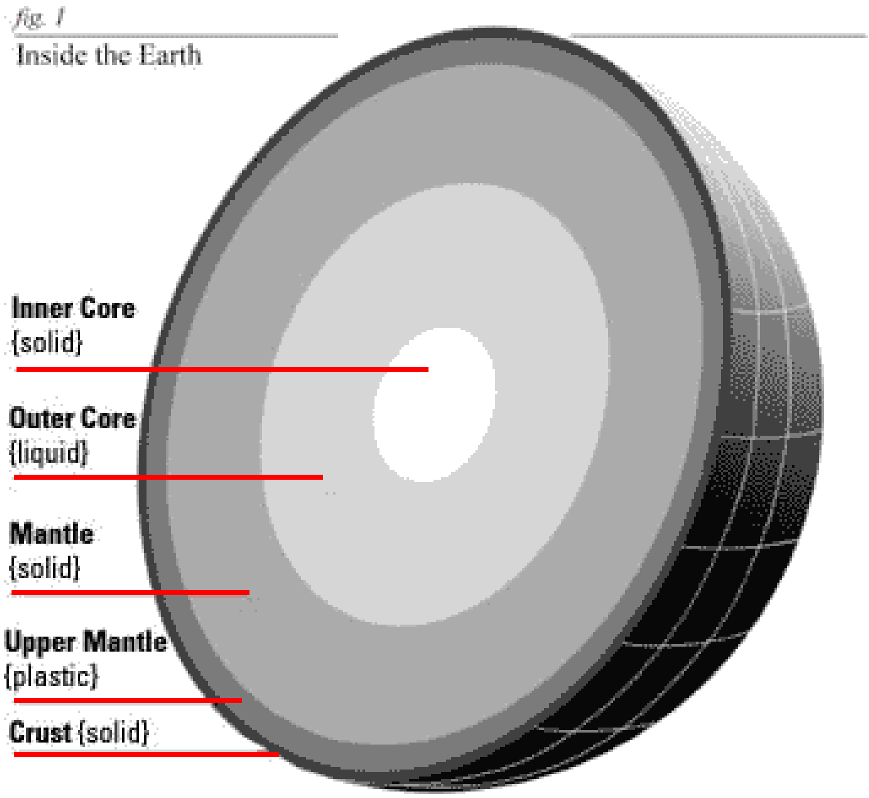

Fig 1: Magma is generated in the Earth's lithosphere, which is made up of the the crust and upper mantle.

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Where Volcanoes Occur

Volcanic eruptions occur only in certain places and do not occur randomly. That's because the Earth's outermost shell - the **lithosphere** - is broken into a series of slabs known as **lithospheric** or **tectonic plates**. These plates are rigid, but they float on the hotter, softer layer in the Earth's mantle. (poster fig. 2) As the plates move about, they spread apart, collide, or slide past each other. Volcanoes occur most frequently at plate boundaries.

Some volcanoes, like those that form the Hawaiian Islands, occur in the interior of plates at areas called **hot spots**. (poster fig. 2) Although most of the active volcanoes we see on land occur where plates collide, the greatest number of the Earth's volcanoes are hidden from view, occurring on the ocean floor along **spreading ridges**.

Mount St. Helens is typical of more than 80 percent of the volcanoes that have formed on land. Known as **subduction zone** volcanoes, they occur along the edges of continents where one plate dives, or subducts, beneath a second plate. (fig. 2). When the subducting plate reaches about 100 kilometers (60 miles) into the Earth's hot mantle, it triggers partial melting of the overlying plate and forms new magma. Some of the magma rises and erupts as volcanoes.

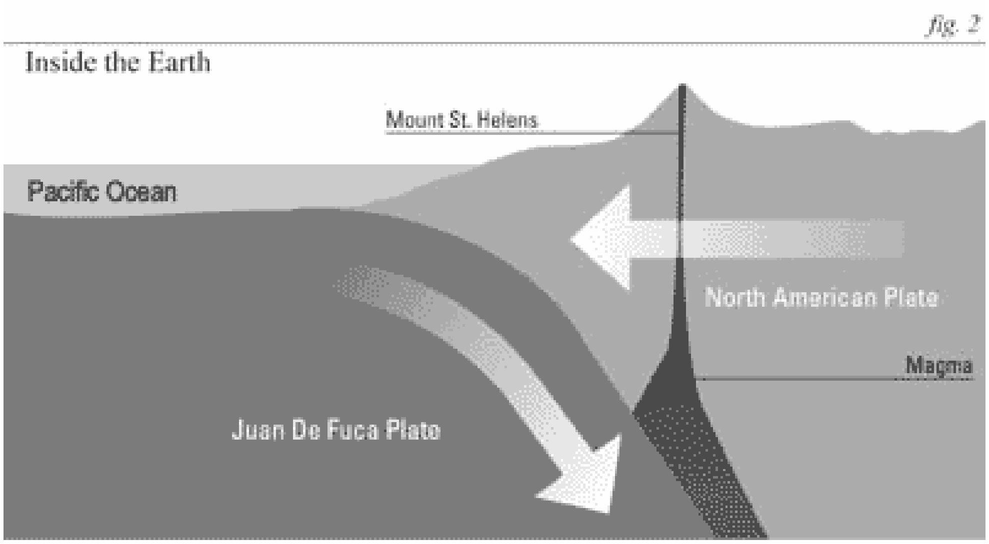

Fig 2: About 240 kilometers (150 miles) west of the northwest coast of the United States, the Joan De Fuca Plage plunges beneath the North American Plate. Mount St. Helen is among the volcanoes that have formed as a result.

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Why Some Volcanoes Erupt

Some volcanoes, like Mount St. Helens, tend to be explosive when they erupt, whereas others, like Hawaii's Kilauea, tend to be effusive (loosely flowing) and nonexplosive. How explosive an eruption is depends on the magma's chemical composition and gas content, which in turn affect the magma's stickiness, or **viscosity**.

All magma contains gases that escape as the magma travels to the Earth's surface. If magma is fluid (as is Kilauea's), gases can escape relatively rapidly. As a result, lava flows instead of exploding during an eruption. If magma is viscous (as is Mount St. Helens), the gases cannot escape easily; pressure builds inside the magma until the gases sometimes escape violently.

In an explosive eruption, the sudden expansion of gases blasts magma into airborne fragments called **tephra**, which can range in size from fine particles of ash to giant boulders. After the initial explosive phase of the eruption, however, quieter lava flows can follow. In both explosive and nonexplosive (effusive) eruptions, volcanic gases, including water vapor, are released into the atmosphere.

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Three Types of Volcanoes

Repeated volcanic eruptions build volcanic mountains of three basic types, or shapes, depending on the nature of the materials deposited by the eruption.

Shield volcanoes (poster fig. 5), such as Kilauea, form by effusive eruptions of **fluid lava**. Lava flow upon lava flow slowly builds a broad, gently sloping volcanic shape that resembles a warrior's shield.

Stratovolcanoes (poster fig.3), such as Mount St. Helens, build from both explosive and effusive eruptions. **Layers of tephra** alternating with layers of viscous lava flows create steep-sided, often symmetrical cones that we think of as the classic volcano shape. In his log of the Lewis and Clark Expedition, William Clark wrote: "Mount St. Helens is perhaps the greatest pinnacle in America."

The smallest volcanoes, **cinder cones** (poster fig. 4), such as Sunset Crater in Arizona, form primarily from explosive eruptions of lava. Blown violently into the air, the erupting lava **breaks apart into fragments called cinders**. The fallen cinders accumulate into a cone around the volcano's central vent. Cinder cones can form on the flanks of shield and stratovolcanoes.

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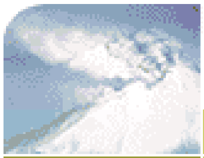


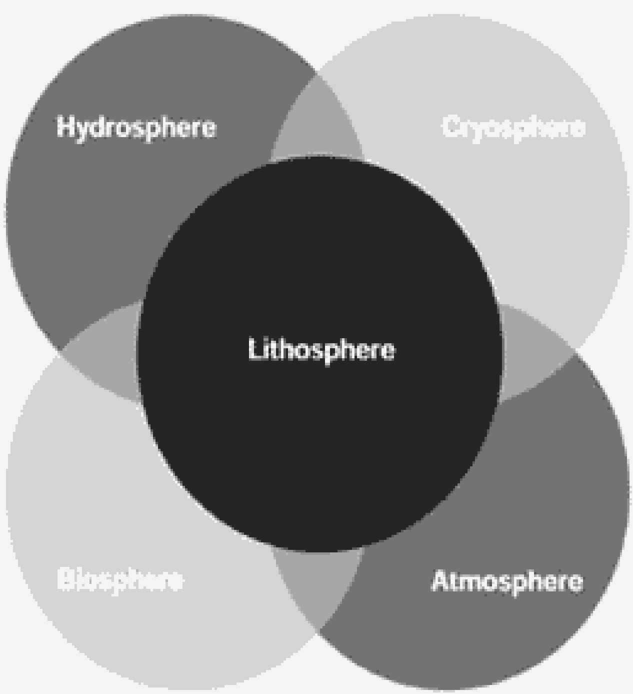
VOLCANOES!

Teacher's Guide and Lessons

Volcanoes is an interdisciplinary set of materials for grades 4-8. Through the story of the 1980 eruption of Mount St. Helens, students will answer fundamental questions about **volcanoes**: "What is a volcano?" "Where do volcanoes occur and why?" "What are the effects of volcanoes on the Earth system?" "What are the risks and the benefits of living near volcanoes?" "Can scientists forecast volcanic eruptions?"

fig. 1

The Earth's Systems



The Earth is a system comprising interactive components.

This teaching packet reflects the goals of the National Science Education Standards developed by the National Research Council. These standards recommend that middle school students be able to understand the Earth as a system. By learning about volcanoes, students will understand that the Earth comprises interacting components, or subsystems: the **geosphere** and the **biosphere**. In turn the geosphere comprises the lithosphere, the atmosphere, the hydrosphere, and the cryosphere. (fig. 1) These lessons show how the eruption of Mount St. Helens affected all of the Earth's subsystems.

Although volcanoes is an earth science subject, the activities in this packet incorporate a number of related subjects, including other sciences, social studies, language arts, and mathematics.

Contents of the online version of the VOLCANOES! teaching packet include:

- Information from the two-sided color poster
- Teaching guide (with glossary and bibliography)
- Six lesson plans with timed activities (activity sheets in PDF format)
- Evaluation sheet

About the poster

(See Introduction page.)

The attractive VOLCANOES! poster is now for sale, call 1-888-ASK-USGS for more information. The poster is a key visual aid for many of the activities. Side 1 is a dramatic photograph of Mount St. Helens erupting on May 18, 1980. Side 2 is a series of photographs and illustrations annotated with text written for student readers. The section titled "Volcanoes" is a basic introduction to volcanoes and volcanic eruptions. The section titled "Mount St. Helens" tells the story of the May 18, 1980, eruption of Mount St. Helens and the effect the eruption had on each of the components of the Earth system. All poster information is available, where appropriate, on this online edition of VOLCANOES!.

Each photograph and diagram has a number. When lessons refer to specific photographs and illustrations, they are referenced as "poster fig." followed by the number of the photograph or diagram.

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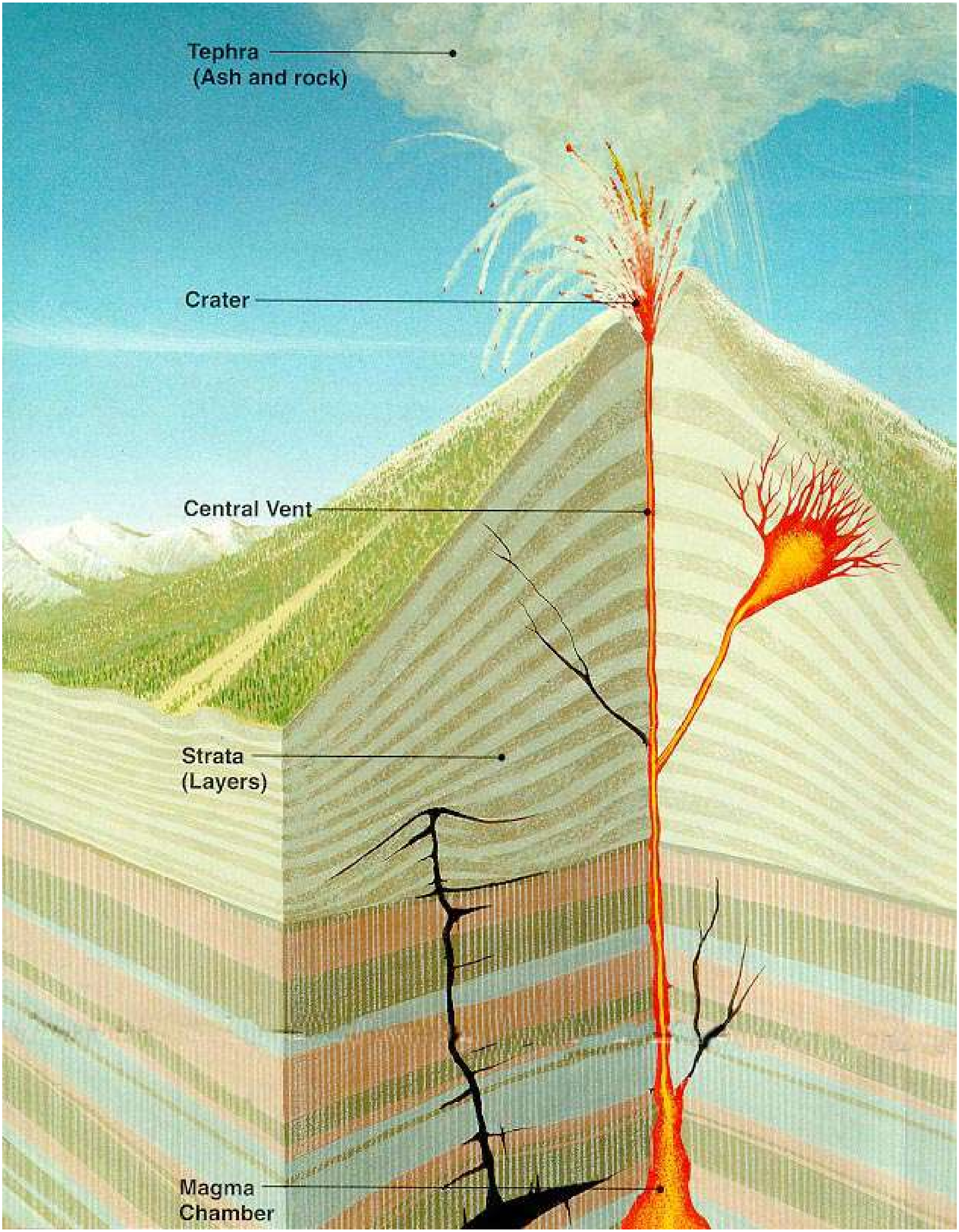
Tephra
(Ash and rock)
Crater
Central Vent
Strata
(Layers)
Magma
Chamber

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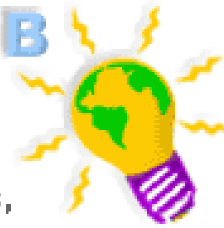

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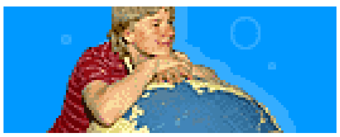

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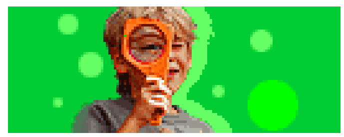

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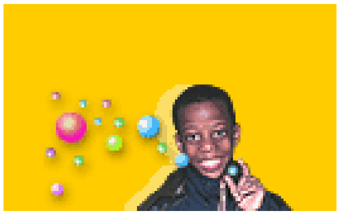

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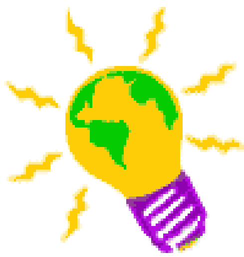

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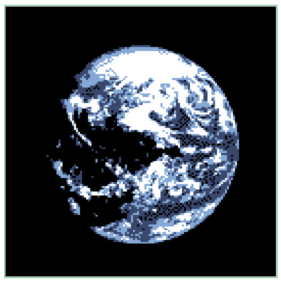

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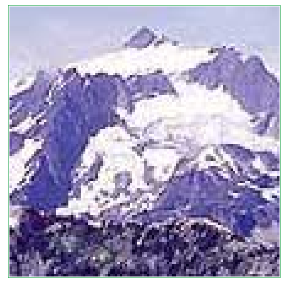

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Virtual Field Trip
Take a virtual field trip to that area along the west-central Florida coast.

Earthquake Hazards Program
Provide and apply relevant earthquake science information and knowledge.

Kids' Earthquake Glossary

Aerial Photographic Gallery
Find aerial photos and landstat images of places, space, hazardous locations, and weather.

Global Environment Outlook 2000
Read reports on what had happened to our environment in year 2000. Report is also available in multiple languages.

Pachamama: Our Earth - Our Future
Teach kids to learn to establish a personal relationship with our Mother, the Earth, and to care for her in the same way that we do for our friends and family.

Earthshots
Earthshots is a collection of Landsat images and text, designed to show environmental changes and to introduce remote sensing.

Coal Country
This kids' education software teaches children the basics about coal. Downloadable online.

Earth Surface Dynamics
Source for ground-based and remotely sensed earth-science data and information used by global-change researchers; assesses of the potential effects of global change on society.

Climatic Impacts
Climatic variability can potentially affect the ecosystems, landscape, water resources, and society of the Southwest. Papers in this section examine aspects of these potential impacts.

National Seismic Hazard Mapping Program
View seismic map images.

Debris-Flow Hazards in the United States
Learn what causes debris flow and how it affects us.

Reducing the Risk From Geomagnetic Hazards
This factsheet describes how and why magnetic storms occur.

Activities to Explore Acid Rain and Building Stones
This 38-page report provides 12 activities for students to explore the effects of acid rain on building stones.

Selected References on Fossils and Paleontology
List of publications, visual, audio, and educational materials.

Information on Fossils and Fossil Collecting
Contains links to information about fossils.

Selected References On Rocks, Minerals, And Gemstones
A list of publications, audios, visuals, and educational materials.

Bedrock Geology and Photo Gallery
Learn about metamorphic sedimentary rocks and see photos.

Geologic Images
Contains images of rocks, fossils, sinkholes, landscapes, and maps.

Paleontology at USGS
Learn about the different types of fossils, how they lived, and how they are used to answer important questions about the world we inhabit.

Books & Other Publications
These pages contain listings of online USGS books, reports, and pamphlets.

Geologic Information
Geologic and mineral resource surveys and mapping for the Department of the Interior.

USGS Geology in Parks
Learn geology basics from touring the national parks.

How Vulnerable Are Seattle Area Lifelines?
Lifelines, such as roads and electrical lines, and earthquake hazards in the greater Seattle area.

The Western Earth Surface Processes Team
Provide the geologic information required to understand the interactions among humans, plants, animals, air, water, soil, and rock on the Earth's surface region.

Surviving a Tsunami—Lessons from Chile, Hawaii, and Japan
This booklet informs how tsunami occurs and draws strategies from survival stories. Only available in PDF.

Table-Top Earthquakes
A demonstration of seismology for teachers and students that can be used to expand lessons in earth science, physics, math, social studies, and geography.

How to Build a Model Illustrating Sea-Floor Spreading and Subduction
Science project for students.

Significant Floods in the United States During the 20th Century
Contains a list of significant floods in the U.S. during the 20th century, plus types of floods.

Landslides
Learn the basics of landslides and recent landslide events.

Landslide Images
View photos of landslides.

Features That May Indicate Catastrophic Landslide Movement
How to watch out for possibilities of landslides.

Scientists in Action
News about careers in the natural sciences -- from mapping the planets to sampling the ocean floor, from protecting wildlife to forecasting volcanic eruption.s

Media for Science
Photo collections of maps, natural disasters, and activities at the USGS.

Coastal and Marine Geology Program
Contains abundant information about coasts, beaches, storms, and marine life.

Earth Science Photographs
Search for rocks, minerals, national parks, monuments, and other geologic images from the photo archive of the USGS.

Understanding Our PlanetThrough Chemistry
USGS site shows how chemists and geologists use analytical chemistry to study Earth.

Mineral Resources Program
Information on the occurrence, quality, quantity, and availability of mineral resources

Minerals Information
Statistics and information on the worldwide supply, demand, and flow of minerals and materials essential to the U.S. economy, the national security, and protection of the environment.

Gemstones
An overview of production of gemstones in the U.S.

Fun Facts About Rocks and Minerals
Contains interesting information on daily use of minerals and rocks.

Panoramic Photographs of Glacier National Park
Gallery of panoramic photographs taken from fire lookout stations in Glacier National Park, Montana during the 1930's.

Landslide Hazards in Glacial Lake Clays - Tully Valley, New York
This factsheet describes the landslide hazard at Tully Valley, New York.

Acid Rain and Our Nation's Capital: A Guide to Effects on Buildings and Monuments
Defines acid rain, explains what effects it has on marble and limestone buildings, and shows through a walking tour some of the places in our Nation's capital where you can see the impact of acid precipitation.

Collecting Rocks
Learn about different types of rocks and how to identify and collect them.

Our Changing Continent
Compares the geological changes of the continent of North America through the ages.

Deserts: Geology and Resources
Describes various types of desert; including extraterrestrial deserts, illustrates various desert features and eolian (wind) processes, and discusses the use of remote sensing in studying deserts and the process of desertification.

Dinosaurs: Facts and Fiction
Do you ever ask "Where did dinosaurs live?" and "Why did dinosaurs grow so big?" Find out here and more!

Earthquakes
This 20-page booklet explains the nature and causes of earthquakes. Describes techniques used to detect, record, measure, and predict seismic disturbances.

The San Andreas Fault
This 17-page booklet defines the San Andreas Fault and also discusses earthquake magnitude and intensity.

The Severity of an Earthquake
Earthquakes are the result of forces deep within the Earth's interior that continuously affect the surface of the Earth. The energy from these forces is stored in a variety of ways within the rocks.

Fossils, Rocks, and Time
USGS publication on the Earth's geologic history.

Natural Gemstones
Basic information about gemstones.

Geologic Time
USGS publication on the Earth's geologic time.

Glaciers: Clues to Future Climate
The relationships between glaciers and climate changes.

Eruptions of Hawaiian Volcanoes: Past, Present, and Future
The volcanic history of the Hawaiian Islands with dramatic, color photographs and diagrams and informative text on Hawaiis active shield volcanoes, Mauna Loa and Kilauea.

Volcanic and Seismic Hazards on the Island of Hawaii
This booklet provides information for the residents of Hawaii so they may effectively deal with the special geologic hazards of the island.

Man Against Volcano: The Eruption on Heimaey, Vestmannaeyjar, Iceland
This 28-page booklet discusses the impact of the 1973 volcanic eruption of Eldfell on the island of Heimaey. (In PDF format.)

Glimpses of the Ice Age from I-81
Know about block fields -- a geologic feature that originated from the Ice Age.

The Great Ice Age
Learn about a period of recurring widespread glaciations on earth. (In PDF format.)

The Interior of the Earth
Understand Earth's structure and composition.

Monitoring Active Volcanos
How scientists track volcanic movements.

The Mountain That Moved
Brochure about several largest landslides in the world. (In PDF format.)

The Geologic Story of the Ocoee River
The geologic story of the rocks exposed along the Ocoee River in Polk County, east Tennessee.

Plain Geology
Article on communicating effectively the results of geologic work to the public in a way that can be understood and used.

Gold
History and basics of gold.

Prospecting for Gold in the United States
Report.

Building Stones of Our Nation's Capital
Describes the source and appearance of many of the stones used in building Washington, D.C.

Volcanoes of the United States
This 44-page booklet describes the principal volcanoes in Hawaii, Alaska, and the Cascades Mountain Range that have erupted during the last few hundred years. Also summarizes recent events at active calderas in California and Wyoming.

Fire and Mud: Eruptions and Lahars of Mount Pinatubo, Philippines
Know all about the eruption history, impacts of the eruption, rocks, and lahars of Mount Pinatubo, Philippines.

Eruptions of Mount St. Helens: Past, Present, and Future
Highlights the eruptive history of this composite volcano, reviews its activity since its awakening in 1980, and speculates about its behavior in the future.

Eruptions of Mount St. Helens: Past, Present, & Future
Highlights the eruptive history of this Mount St. Helens.

This Dynamic Earth: The Story of Plate Tectonics
This colorfully illustrated 77-page booklet complements the "This Dynamic Planet"

poster and describes in detail the various aspects of plate tectonics.

Exploring Earthquakes: Online Glossary

USGS by State
Find geological, biologcial, mineral, and water information; also maps and streamflow of each State of U.S.

The Geology of Radon
Present information about radon, how it forms, where it comes from, how it moves, and how to estimate its amount in an area.

South Florida Information Access
Provides geological and biological information for the South Florida region.

South Florida Virtual Tour
View beautiful habitat, plants, and animals of South Florida.

A Tapestry of Time and Terrain
View earth surfaces through digital collage of geology and topography maps.

TerraWeb for Kids
Satellite and sonar images, remote-sensing education, and activities for kids!

USGS Volcano Hazards Program
A comprehensive overview of the U.S. Geological

Description of Program Videos
A list of videos produced by USGS

Photo Glossary of Volcano Terms
A picture speaks a thousand words. Learn volcano terms with images and photos.

Cascades Volcano Observatory
Focuses on hazards, activity, history, and monitoring of volcanoes, with emphasis on volcanoes of the Western United States.

Volcano and Hydrologic Hazards, Features, and Terminology
Contains detailed background info and photos of volcanic features and terms.

Current Volcanic Activity
Contains a list of sites with real-time volcano monitoring.

Photo Archives of Volcanoes
Numerous photos of various volcanoes, live images, eruption features, volcanic monitoring equipments, and more...

VolcanoCams Around the World
"Live" views of volcanoes from around the world, including Europe and Japan.

Ask-a-Geologist
Get your geological questions answered by geologists

Coastal and Marine Geology: Education & Outreach
Links to classroom activities and other education information.

Tsunamis and Earthquakes
General information on how earthquakes generate tsunamis and summaries of tsunami research using animations and VRML models

Floods and Flood Plains
Contains general background information on floods.

Hazards Fact Sheets
Documentations and reports of natural disasters.

The Chesapeake Bay Bolide: Modern Consequences of an Ancient Cataclysm
Find out about bolides, or extraterrestrial bodies, and the impacts they have on earth.

Geologic History of Cape Cod, Massachusetts
History and animals of Cape Cod, from the Great Ice Age to today.

Geologic History of Cape Cod, Massachusetts
Describes the glacial formation of Cape Cod, Massachusetts, and the ever-changing shore as the Cape adjusts to the rising sea.

USGS Teacher's Guide to the San Francisco Bay Area Map
Teaching guide to describe the gravity and magnetic fields of the Bay area; discusses how earth scientists use gravity and magnetism to "see" beneath surface of the Earth.

Karst Topography
Illustrates, through computer animation and a paper model, why caves develop in limestone.

Glaciers
Informative page on how glaciers grow and various types. Contains a gallery of illustrations and photos.

What Are Volcano Hazards?
Understand how volcanoes endanger us.

Popular Beach Disappears Underwater in Huge Coastal Landslide
Fact sheet documents how a landslide happened.

Earthquake ABC: A Child's View of Earthquake Facts and Feelings
A pictorial glossary for young kids with a complementary parents guide.

Agate Fossil Beds
Produced by National Park Service's Division of Publication, this book provides a glimpse of that time, long before the arrival of man, when now-extinct creatures roamed the land which we know today as Nebraska.

Effects of Fire in the Northern Great Plains
A literature review concerning fire effects on the grassland biome of the Northern Great Plains, with special emphasis on the use of fire for wildlife management.

Wetland Science Lesson Plans
Provides lesson plans that focus upon topics ranging from wetlands science to microscopy to graphing calculators.

Making a World of Difference
Records recent USGS contributions to the Nation.

GeoMedia
An earth-science educational tool for students between the ages of 10 and 14.

Earthquakes and Other Natural Hazards
Learn about earthquakes and other hazards and find out how to prepare for these hazards.

USGS Hurricanes and Coastal Storm Websites
Links to USGS sites that are related to hurricanes and storms.

Picturing Science
A collection of photographs that creates six tours that focus on different aspects of science and include: Magnificent Waterways, Phenomenal Landscapes, Wonderful Wildlife, Changing Worlds, Earth Scientists, and Popular Products.

Science Challenge Questions and Answers
A collection of 196 questions and answers addressing earth and planetary science topics.

Student Employment Web Site
Information about the USGS and its programs, student employment options, major occupations and their qualifications, salaries, benefits, career fair tips and interviewing techniques are located on the USGS Student Employment Web Site.

Hazards
Links to various hazards reports, including earthquake, volcanoes, flood, landslides, wildfire, wildlife diseases, geomagnetism, and coastal storms and tsunamis.

Wildland Fire Research
Find out how wildland fire affects the environment.

Fire Ecology Research
To restore more normal fire dynamics to a particular region, managers need to know how fire has historically affected the local system, and how it functions today. See research reports here.

Flagstaff Field Center
Reports of various geoscience studies.

Geologic animations
Animations include plate tectonics, gas, oil, and more.

Park Geology Teacher's Features
Teaching geology with national park examples.

Park Geology Tour of National Parks
Learn geology through online tour of national parks.

Windows to the Universe
Fun and intriguing site about the earth and space sciences.

Geologic Photo Search

Search photos of national parks.

A Model of Sea-Floor Spreading Teacher's Guide
Make a paper model illustrating the concept of sea-floor spreading.

Playtime for Kids
Connects to a bunch of exciting online games!

Earth Science Classroom Activities
Classroom activities on geology-related subjects for grades k-3.

The Fragile Fringe
Lesson plans and activities to teach students about wetlands.

More Than Skin Deep
A teacher's guide to caves.

NOAA Photo Library
Contains a vast variety of pictures from animals to landscape, the Arctic to China, space to ocean, historical art to satellite images and more.

Photo Library of National Oceanic and Atmospheric Administration
Find photos and images of wildlife, environment, fishery, landscape, ships, space, weather, and much more!

New Millennium Observatory Education Page
Features a curriculum for high school and middle school students based on the daily reports from expedictions at sea and NeMo results.

The EarthPulse Center
Interactive learning tool for earthquake location, magnitude, distribution and forecasting.

Science NetLinks
Connects to a library of online lessons.

Glacier National Park
Take an electronic field trip to the crown jewel of the Rockies.

Museum of Paleontology
Learn about fossils and earth history through background information and collection of fossils. Contains activities for both the classroom and students.

Learning From the Fossil Record
Fun education site about paleontology and earth-science.

Science Activities
Science activities for teachers and students. Topics include earth science, bioscience, physcial science, computers, and more.

Franklin Institute Earth Science Resources
Links page to abundant geology resources onlines.

Photo Gallery of Mount St. Helens
View over 190 photos of Mount St. Helens' landscape and wildlife before and after

eruption.

Wired Antarctica
Learn about the people doing research in Antarctica, what it's like there and how their research is important. Learn also how glaciers work in a series of lesson plans.

GLOBE: Global Learning and Observations to Benefit the Environments Education Program
Teachers and students -- help scientists by sending your scientific data and observations to their data archive.

Geostationary Satellite Server
NOAA's real-time satellite weather images.

IRIS Education and Outreach
Geology education page for teachers self learners.

Mineralogical Society of America
Contain articles on mineralogy and activities for kids.

Collector's Corner
See how and where you can collect rocks.

Official State Geologic Symbols
Find out your state rock, mineral, gem, and fossil, and learn more about them.

Mineralogy 4 Kids
Learn about minerals and play games.

Ask-A-Mineralogist
A forum where real mineralogists answer your questions.

E-cards of Natural Disasters
Send e-cards on images of volcanoes, earthquakes, tsunamis, and landslides.

World-Wide Tropical Cyclone Names
What's in a name? Find out the reserved names for hurricanes and typhoons.

National Hurricane Center: Tropical Prediction Center
Contains recent and historical storm information, weather forecast, maps, and satellite images.

National Oceans and Atmosphere Administration Homepage
Come here to learn about global weather, oceans, fisheries, and view real-time information.

American Geological Insititute Education
Produce innovative inquiry-based curriculum for K-12 earth science education.

Athena, Earth and Space Science
K-12 education page for teachers and students.

Bureau of Land Management
The Bureau of Land Management administers 264 million acres of public lands containing natural, historical, cultural, recreational, and economic resources.

Geo Mysteries with Rex, the Dino Detective
Fun and interactive geologic site for kids.

Post Card Tours of National Parks
View national parks from post card images.

Photo Library Resources
Link to various image galleries from the Department of Interior.

Earth Science Activities
Contains classroom activities including creating a model of the Earth's interior, identifying minerals, and more.

Kids Game Page
Have a blast with FEMA's online games, stories, and hands-on activities!

Earthforce
Informative site about forces that cause eruptions, quakes, and floods.

A Teacher's Guide to the Geology of Hawaii Volcanoes National Park
Contains information and classroom activities about plate tectonics, volcanoes, hot spots, mantles, lava, and more.

SCEC Earthquake Education Module
Site for high school- and undergraduate-level students. Contains info, graphics, and activities that explain how earthquakes happen.

Tectonic Plates Education Module
Contains information, animations, and student activities about tectonic movements of the Earth's surface.

Image Gallery from the U.S. Fish and Wildlife Service
Find images of fishes, wildlife, duck stamps, landscapes, and more.

This Planet Really Rocks
Know all the basics about rocks and rock collecting.

Echo the Bat
Understand light, remote sensing, and biodiversity.

Global Change Master Directory
A comprehensive directory of information about global change, such as global warming.

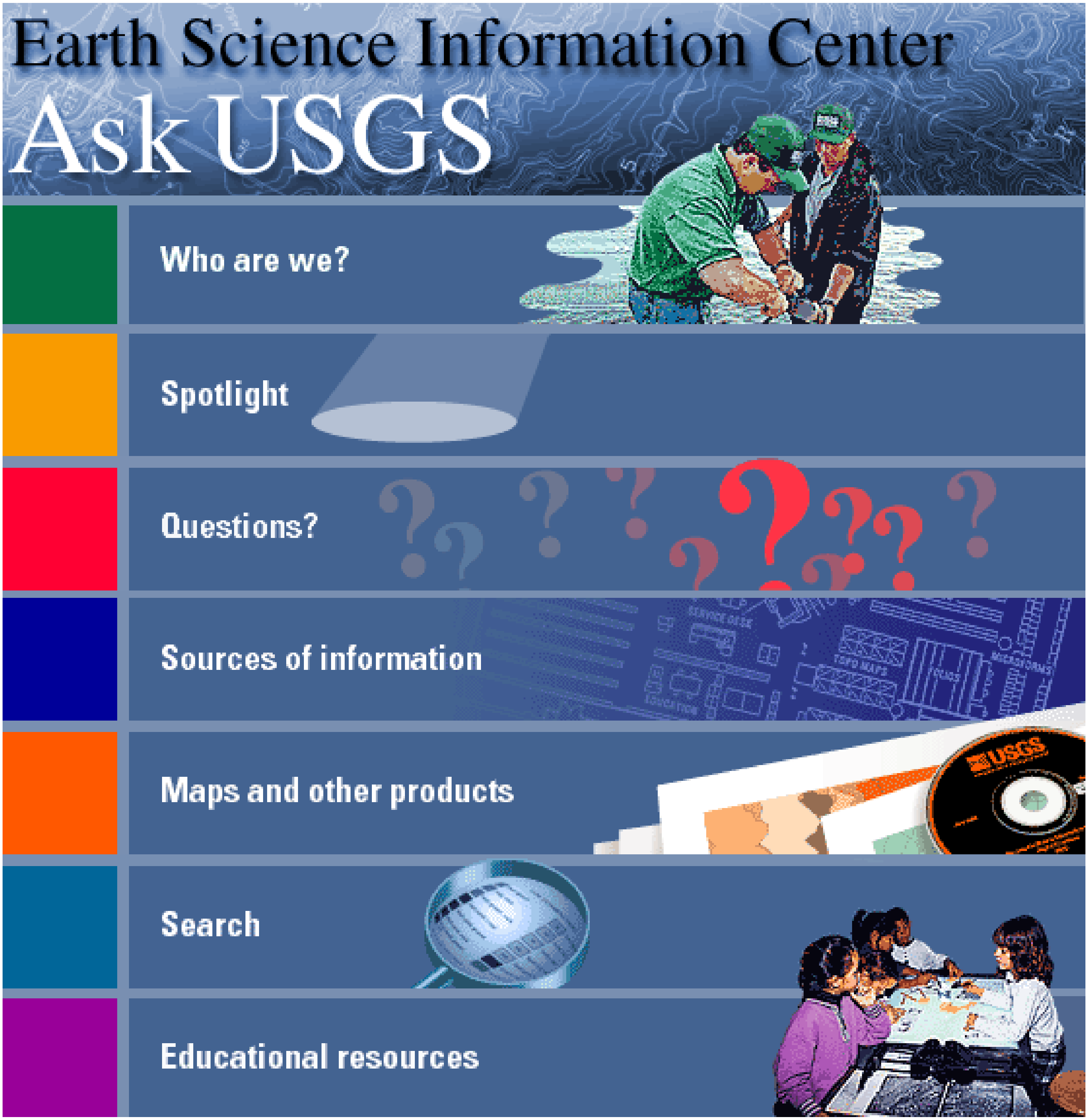
Earth from Space: Astronauts' Views of the Home Planet
Search photos taken from space from a database of over 375,000 images.

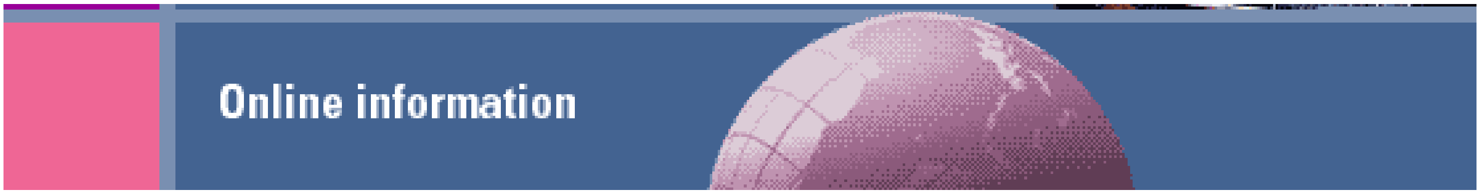
U.S. Department of the Interior, U.S. Geological Survey, Reston, VA, USA

URL: http://www.usgs.gov/education/index.html
Earth science questions: http://www.usgs.gov/ask/index.html
Page contact: Learning Web Team
Last modified: 16:30:00 Tue 29 Jan 2002 act

USGS
science for a changing world

Text Version





U.S. Department of the Interior
U.S. Geological Survey
12201 Sunrise Valley Drive, Reston, VA 20192, USA
URL: http://ask.usgs.gov /index.html
Page Maintainer: Ask USGS Web Team
Contact: http://www.usgs.gov/contact
Last modified: 11:57:05 Fri 06 Sep 2002
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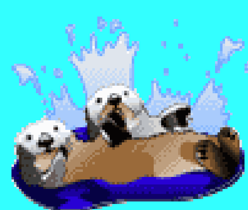
Fun Stuff

Image Wizard

Need images for your research? Image Wizard can help you find them.

Playtime Wizard



Come have fun with the Playtime Wizard. Many fun games and activities await you.

Map Wizard

Let Map Wizard help you generate your own map or search for a USGS map.

E-Safe Card

Send an environmentally safe greeting to your friends and family.

Wallpapers

Decorate your desktop with images of natural sceneries and wildlife.

Search Wizard

Access numerous online references using the Search Wizard.

THE LEARNING WEB

Basic Search

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Ask USGS

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Image Wizard
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E-Cards
Wallpapers

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Water
Plants & Animals
Maps & Images
Rocks & Images
Real-time Info
Ecosystems
Natural Resources

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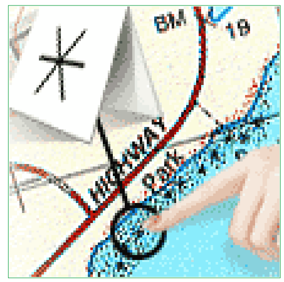
Fun Stuff > Playtime Wizard

Link to USGS sites.
Link to non-USGS sites. We are happy to provide this link for your convenience. Please be aware that we cannot guarantee the accuracy of non-USGS sites.

Featured Sites

Learning Web Coloring Pages
Download printable coloring pages.

Learning Web Trivia Game
Challenge your brain with questions about the Earth.



Learning Web Topo Bingo
Learn topographic map symbols.

The Learning Room
Designed especially for mid-elementary-school-aged kids and up. Learn about all kinds of biologically related subjects.

Pacific Island Ecosystems Research Center
Study of wildlife and ecosystems in Hawaii.

Earthquake Hazards Program
Provide and apply relevant earthquake science information and knowledge.

Water Science for Schools
Find information on many aspects of water, along with pictures, data, maps, and an interactive center.

USGS South Florida Ecosystem / Kids' Corner
Games, photos, and dictionary for kids.

Paleontology at USGS
Learn about the different types of fossils, how they lived, and how they are used to answer important questions about the world we inhabit.

South Florida Information Access

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Wallpapers

Provides geological and biological information for the South Florida region.

TerraWeb
View image and information generated using remote sensing in various Earth environments.

TerraWeb for Kids
Satellite and sonar images, remote-sensing education, and activities for kids!

Coastal and Marine Geology: Education & Outreach
Links to classroom activities and other education information.

Midcontinent Ecological Science Center
Contains articles on scientific researches and education pages for kids.

Northern Prairie Wildlife Research Center
Information for wildlife managers, scientists, and the public on natural-resource issues and biota of the North American Great Plains.

Wetland Science Lesson Plans
Provides lesson plans that focus upon topics ranging from wetlands science to microscopy to graphing calculators.

Water Jeopardy
Jeopardy game with water as the topics.

Museum of Paleontology
Learn about fossils and earth history through background information and collection of fossils. Contains activities for both the classroom and students.

Windows to the Universe
Fun and intriguing site about the earth and space sciences.

Playtime for Kids
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NASA's Observatorium Fun & Games
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The EarthPulse Center
Interactive learning tool for earthquake location, magnitude, distribution and forecasting.

Mineralogy 4 Kids
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Mineralogical Society of America
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GLOBE: Global Learning and Observations to Benefit the Environments Education Program
Teachers and students -- help scientists by sending your scientific data and observations to their data archive.

Groundwater Basics

Explore These...
Earth Hazards
Water
Plants & Animals
Maps & Images
Rocks & Images
Real-time Info
Ecosystems
Natural Resources

Contains information about ground water, glossary, issues, youth program, and ways to conserve and protect ground water. Includes kids section.

Ground Water Basics Kids Corner
Contains home and classroom experiments, question and answering, and puzzles.

Children's Butterfly Site
Developed for grades 4-6. Information is given on moths and butterflies, along with a coloring page, frequently asked questions and answers, a gallery of butterfly photographs, and links to other sites.

Athena, Earth and Space Science
K-12 education page for teachers and students.

Geo Mysteries with Rex, the Dino Detective
Fun and interactive geologic site for kids.

Kids Game Page
Have a blast with FEMA's online games, stories, and hands-on activities!

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Fun Stuff > Image Wizard

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Featured Sites

Learning Web Clipart
Download the fun cliparts that you see throughout the Learning Web and use them for your own project.

Media for Science
Browse photos of landscape, waterways, wildlife, weather, scientists, and more...

Printable Bookmarks
Download these colorful and educational bookmarks.

USGS Biological Resources Division
Page links to programs, publications, photo galleries, and more.

Center of Coastal Geology
Contains online student activities, education resources, and publications.

Mapping Coastal Change Hazards
An illustrated discussion of coastal change hazards and the work that the U.S. Geological Survey is doing to map and understand these hazards.

Navassa Island: A Photographic Tour
Several thematic photographic tours of the Caribbean island of Navassa, compiled from photographs.

A Photo Gallery of Florida's Big Bend Tidal Wetlands
Photo gallery of the Gulf of Mexico Tidal Wetlands research project at the USGS Center for Coastal Geology, St. Petersburg, Florida

Aerial Photographic Gallery
Find aerial photos and landstat images of places, space, hazardous locations, and weather.

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- Ask USGS

Fun Stuff

- Playtime Wizard
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- Map Wizard
- E-Cards
- Wallpapers

Water Science for Schools
Find information on many aspects of water, along with pictures, data, maps, and an interactive center.

USGS South Florida Ecosystem / Kids' Corner
Games, photos, and dictionary for kids.

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Toxic Water Photo Gallery
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VolcanoCams Around the World
"Live" views of volcanoes from around the world, including Europe and Japan.

Coastal and Marine Geology: Education & Outreach
Links to classroom activities and other education information.

The Whooping Crane Report
Regularly updated reports on breeding whooping cranes.

Glaciers
Informative page on how glaciers grow and various types. Contains a gallery of illustrations and photos.

Sea Birds Photo Gallery
View photos of sea birds.

Northern Prairie Wildlife Research Center
Information for wildlife managers, scientists, and the public on natural-resource issues and biota of the North American Great Plains.

North American Reporting Center for Amphibian Malformations
Information on the issue of malformed amphibians, including a current map of the situation in the United States and Canada, and current literature and news articles.

What do the malformations of amphibians look like?
Photos that illustrate different types of abnormalities and malformations on amphibians, such as frogs and lizards.

Caterpillars of Eastern Forests
Includes species descriptions, life cycle and morphology information, and tips on photographing, rearing, collecting, and preserving specimens of many caterpillars living in forests of the eastern United States.

Caterpillars of Pacific Northwest Forests and Woodlands
A field guide to caterpillars commonly found in forests and woodlands of the Pacific Northwest, including sections describing the natural history, nomenclature, identification keys, and details for collection and preservation of specimens.

Butterflies of North America
Contains species photo gallery, information, and maps as to where butterflies appear.

Butterflies of North America
View over 500 photos of butterflies and species descriptions.

Moths of North America
Know more about moths, what they look like, where they live, and how they live.

Western Wetland Flora
Field guide containing color photographs, line drawings, distinquishing features, range maps, and textual descriptions for 300 species of wetland plants that live in the

western U.S.

Northern Prairie Biological Resources
List of information on the biotic resources of the Great Plains for decisionmakers, resource managers, scientists, and the public.

The Patuxent Plant List and Herbarium Collection
Its photo gallery contains a large collection of plants.

Picturing Science
A collection of photographs that creates six tours that focus on different aspects of science and include: Magnificent Waterways, Phenomenal Landscapes, Wonderful Wildlife, Changing Worlds, Earth Scientists, and Popular Products.

A Field Guide to the Reptiles and Amphibians of Coastal Southern California
Contains species photos, field guides, and illustrated glossary of amphibians and reptiles.

Flagstaff Field Center
Reports of various geoscience studies.

Maui Fog Research
Cloud forest hydrology

Student Employment Web Site
Information about the USGS and its programs, student employment options, major occupations and their qualifications, salaries, benefits, career fair tips and interviewing techniques are located on the USGS Student Employment Web Site.

Geologic Photo Search
Search photos of national parks.

Park Geology Tour of National Parks
Learn geology through online tour of national parks.

Windows to the Universe
Fun and intriguing site about the earth and space sciences.

NOAA Photo Library
Contains a vast variety of pictures from animals to landscape, the Arctic to China, space to ocean, historical art to satellite images and more.

Photo Library of National Oceanic and Atmospheric Administration
Find photos and images of wildlife, environment, fishery, landscape, ships, space, weather, and much more!

New Millennium Observatory Education Page
Features a curriculum for high school and middle school students based on the daily reports from expedictions at sea and NeMo results.

National Oceans and Atmosphere Administration Homepage
Come here to learn about global weather, oceans, fisheries, and view real-time information.

Children's Butterfly Site

Developed for grades 4-6. Information is given on moths and butterflies, along with a coloring page, frequently asked questions and answers, a gallery of butterfly photographs, and links to other sites.

The National Biological Information Infrastructure (NBII)
Use the NBII to answer a wide range of questions related to the management, use, or conservation of this Nation's biological resources.

Post Card Tours of National Parks
View national parks from post card images.

Photo Library Resources
Link to various image galleries from the Department of Interior.

Photo Gallery of Mount St. Helens
View over 190 photos of Mount St. Helens' landscape and wildlife before and after eruption.

Geostationary Satellite Server
NOAA's real-time satellite weather images.

Arctic Theme Page
Provides access to widely distributed Arctic data and information for scientists, students, teachers, academia, managers, decisionmakers and the general public.

Image Gallery from the U.S. Fish and Wildlife Service
Find images of fishes, wildlife, duck stamps, landscapes, and more.

Earth from Space: Astronauts' Views of the Home Planet
Search photos taken from space from a database of over 375,000 images.

Fun Stuff > Map Wizard

Link to USGS sites.
Link to non-USGS sites. We are happy to provide this link for your convenience. Please be aware that we cannot guarantee the accuracy of non-USGS sites.

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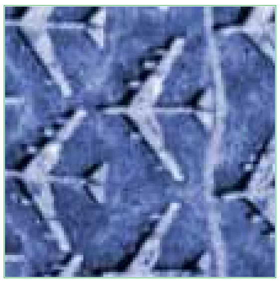
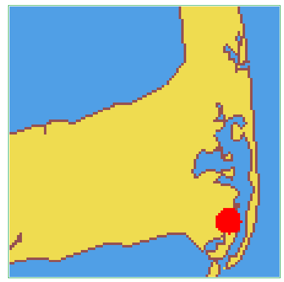


Microsoft TerraServer
TerraServer provides free online access to USGS digital aerial photographs and to digital topographic maps.

National Atlas
Search for maps designed to stimulate children and adults to visualize and understand complex relationships between environments, places, and people.



Map-It
Plot the longitude/latitude numbers to generate a Mercator projection map with land/sea and political boundaries.

Map-it
Plot in the longitude/latitude numbers to generate a Mercator projection map along with land/sea and political boundaries.

Earthshots
Earthshots is a collection of Landsat images and text, designed to show environmental changes and to introduce remote sensing.

Geologic Information
Geologic and mineral resource surveys and mapping for the Department of the Interior.

Why Geologic Maps are Made and How They are Used
Places where geologic maps are used.

Topographic Map Symbols
Learn to read topographic maps.

Historic Mapping

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Natural Resources

Learn who uses historical maps and where to find them.

Map Accuracy Standards
Describes how the USGS maintains map accuracy.

USGS Information Products About Mapping and Related Subjects
Contains links describing USGS cartographic and geographic products and programs.

Media for Science
Photo collections of maps, natural disasters, and activities at the USGS.

National Mapping Information
Link to maps, aerial photography, satellite photography, reports, USGS products, and education pages.

Digital Backyard -- Mapping Information
Pertains information about various types of maps, including topographic maps, aerial photographs, digital raster graphics, and digital orthophoto quadrangles.

Digital Raster Graphics Downloads
Obtain free digital raster graphics for your state.

USGS Topographic Maps
Contains background information on topographic maps and teaches map reading.

National Geological Map Database
We can help you find information about maps and related data for: geology, hazards, earth resources, geophysics, geochemistry, geochronology, paleontology, and marine geology.

Maps on Demand
Find maps of U.S. maps and how to order them.

Rocky Mountain Mapping Center: Education and Outreach
Contains lesson plans, classroom activities, and educational resources

A Tapestry of Time and Terrain
View earth surfaces through digital collage of geology and topography maps.

TerraWeb for Kids
Satellite and sonar images, remote-sensing education, and activities for kids!

USGS Teacher's Guide to the San Francisco Bay Area Map
Teaching guide to describe the gravity and magnetic fields of the Bay area; discusses how earth scientists use gravity and magnetism to "see" beneath surface of the Earth.

National Atlas
Search for maps designed to stimulate children and adults to visualize and understand complex relationships between environments, places, and people.

Digital Orthophoto Quadrangle (DOQ) -- Mapping Information
Find out what is a DOQ and see examples.

Maps of the United States
Descriptions and illustrations of some USGS maps of the United States with

examples of possible uses.

Maps of the World
Descriptions and illustrations of some USGS maps of the world with examples of possible uses.

Earthquakes and Other Natural Hazards
Learn about earthquakes and other hazards and find out how to prepare for these hazards.

Animated Map
This map shows the combined effect of all six hazards--earthquake, volcanic, landslides, flooding, hurricane, and tornado. Watch as the distribution of each is added to the previous hazards.

Johnson Creek Hydrologic Monitoring
Johnson Creek Hydrologic Monitoring

Park Geology Tour of National Parks
Learn geology through online tour of national parks.

Topographic Map Symbols
Links to topographic map examples which illustrate symbols commonly used on maps for cultural and natural features.

Microsoft TerraServer
TerraServer provides free online access to USGS digital aerial photographs and to digital topographic maps.

National Atlas
Search for maps designed to stimulate children and adults to visualize and understand complex relationships between environments, places, and people.

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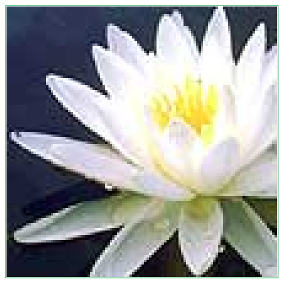
Send beautiful wildlife E-Cards with real stamps!



NBII Postcards
Email greetings from a selection of nature photos.

Wildlife E-Cards
Find a wildlife in every event...

Postcards From the Prairie
Send beautiful wildlife e-cards with real stamps!

E-cards of Natural Disasters
Send e-cards on images of volcanoes, earthquakes, tsunamis, and landslides.

NASA's Observatorium Postcards
Send special occasion cards to friends.

Windows to the Universe
Fun and intriguing site about the earth and space sciences.

NASA's Virtual Postcard of Planets
Greet your friends with fun e-cards of space, planets, comets, mythology, space missions, and more!

Aeronautics Cyberpostcards
Send cool images of NASA's aviation equipments to friends.

Wildlife E-Cards
Find wildlife in every event...

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NBII Postcards
Email greetings from a selection of nature photos.

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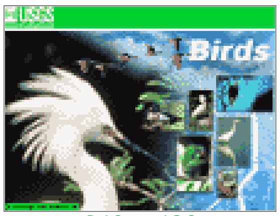
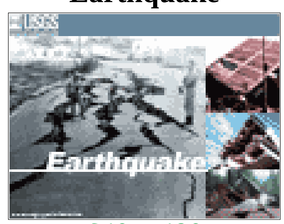
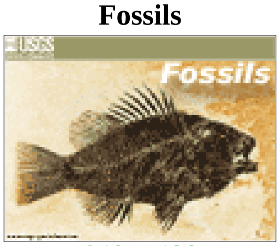
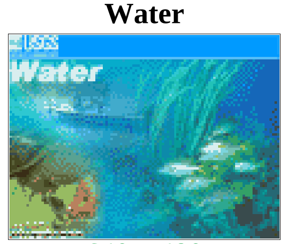
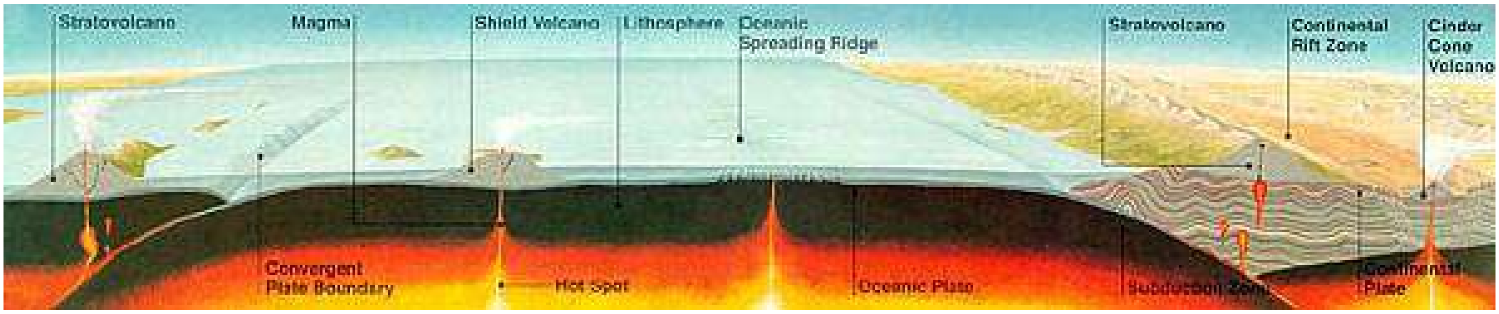
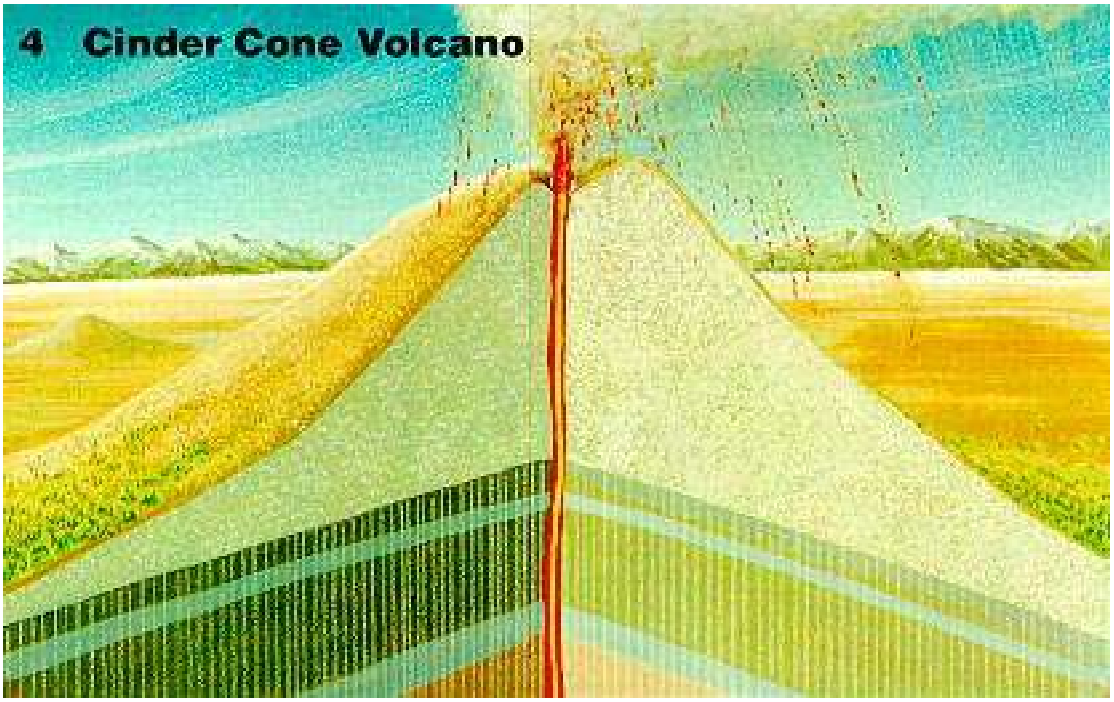
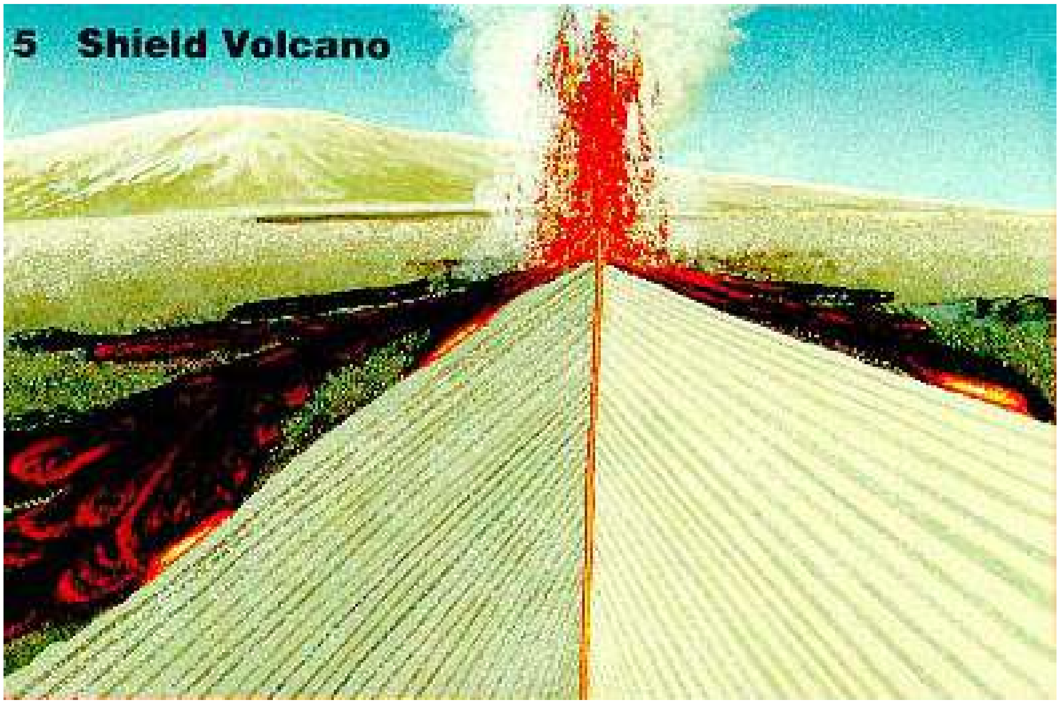
Birds  640 x 480 800 x 600 1024 x 768	**Wildlife**  640 x 480 800 x 600 1024 x 768	**Scientists**  640 x 480 800 x 600 1024 x 768
Landscape  640 x 480 800 x 600 1024 x 768	**Volcanoes**  640 x 480 800 x 600 1024 x 768	**Earthquake**  640 x 480 800 x 600 1024 x 768
Fossils  640 x 480 800 x 600 1024 x 768	**Maps**  640 x 480 800 x 600 1024 x 768	**Water**  640 x 480 800 x 600 1024 x 768


Stratovolcano
Magma
Shield Volcano
Lithosphere
Oceanic
Spreading Ridge
Stratovolcano
Continental
Rift Zone
Cinder
Cone
Volcano
Convergent
Plate Boundary
Hot Spot
Oceanic Plate
Subduction Zone
Continental
Plate


3 Stratovolcano


4 Cinder Cone Volcano


5 Shield Volcano

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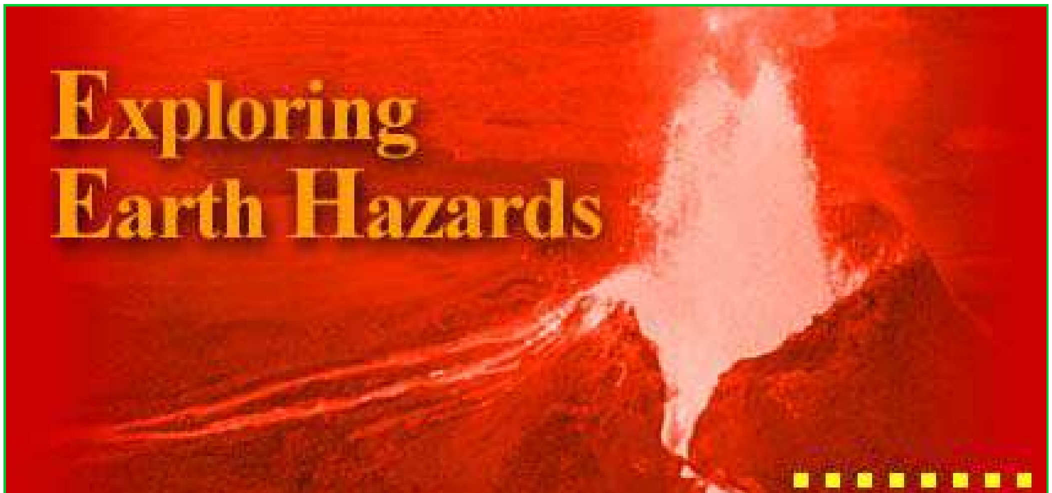

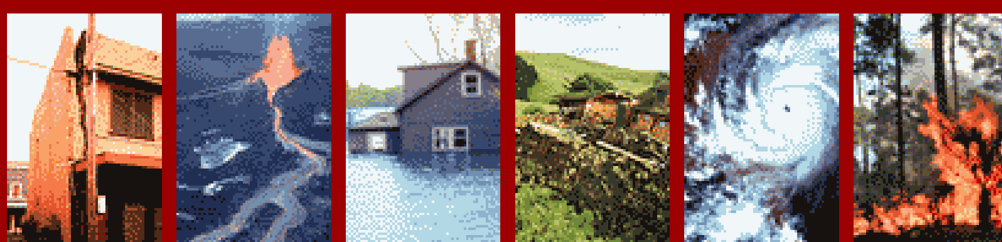

Earthquakes Volcanoes Floods Landslides Storms Fire

Understanding the mechanisms of natural events, such as earthquakes, volcanic eruptions, landslides, and floods, is important for the United States and the world at large. Natural disasters have cost the U.S. alone 50 billion dollars in recent years. By better understanding why natural events occur, we can plan and manage in ways that will lessen the severity of these hazards. Through scientific research, earth science educational programs, and societal planning and preparedness, not only will the damaging effects of natural hazards be reduced, but we will better understand the Earth on which we live.

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Explorers > Special Topics

- Abstract from USGS Water Education Posters

Looking at water, you might think that it's the most simple thing around. Pure water is colorless, odorless, and tasteless. But it's not at all simple and plain and it is vital for all life on Earth. Where there is water there is life, and where water is scarce, life has to struggle.

Water Use

Water truly is a resource that gets used and used for everything. The same water can be utilized many times.

From the mountains, the river flows through a reservoir and past urban, rural, and industrial settings. Water is available from surface sources, such as rivers, ponds, and lakes, and from ground-water sources called aquifers.

Recreation, hydroelectric power generation, nature's needs, and transportation are instream uses, which means that the water remains in the river. Consequently, very little water is consumed. The water can be reused farther downstream. Mining, public supply, commercial, domestic, wastewater-treatment, agriculture, thermoelectric power generation, and industrial are offstream uses, which means that the water is withdrawn from a source such as the river or ground. But only a part of the water withdrawn is actually consumed, so the remaining part is returned to the river or ground and can be used again. Different offstream uses consume different proportions of the water they withdraw.

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Water Quality

What is water quality? To some people, water quality may suggest only "clean" water for drinking, swimming, and fishing. But to the farmer or manufacturer, water quality may have an entirely different meaning. One of the most important issues concerning the quality of water is how that water will be used. Water that is perfectly fine for irrigation might not be suitable for drinking or swimming.

The quality of water can change as it flows over the land surface as rivers, streams, lakes, or ponds (surface water), or under the land surface (ground-water). Because surface and ground waters are interconnected in some areas, changes in the quality of surface water can affect the quality of the area's ground-water, and vice versa. These changes in water quality may be due to natural factors or human activities.

As rock minerals come in contact with water, some dissolve and become part of the surface- or ground-water system. Other natural materials, such as soil or organic matter, become suspended in the water and move from one place to another. The effects of human activities on water may result from land disturbances, which increase the amount of rock minerals, soils, or organic matter available to be transported by and dissolved in water, or from the addition of human-made pollutants. When water is degraded to a point that affects its use for a particular purpose, it has become polluted.

Water pollution originates from two very different sources: point sources and nonpoint sources. Human activities are associated with point sources (wastewater-treatment plant, storm drain, and factory) and nonpoint sources (suburban lawn, parking lot, construction site, landfill, logging area, septic tank, and agricultural field).

Learn more about Water.

U.S. Department of the Interior, U.S. Geological Survey, Reston, VA, USA
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Our lives are interlinked with the plants and animals in our surroundings. The ever-expanding human population, with needs for land, water, resources, and recreation, conflict directly with the habitat requirements of many species. By understanding cause-and-effect relationships between natural and human impacts on biological resources, we are able to interpret trends and work with resource managers to evaluate options to correct problems.

Find out more about plants and animals at the sites below:

U Link to USGS sites.
Link to non-USGS sites. We are happy to provide this link for your convenience. Please be aware that we cannot guarantee the accuracy of non-USGS sites.

Featured Sites

Northern Prairie Biological Resources
List of information on the biotic resources of the Great Plains for decision makers, resource managers, scientists, and the public.

Amphibian Declines and Deformities
Links to researches on amphibian deformities and answers frequently asked questions on the issue.

The National Biological Information Infrastructure
Use the NBII to answer a wide range of questions related to the management, use, or conservation of this Nation's biological resources.

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Ecosystems
Natural Resources

Alaska Biological Science Research
Provide biological information and research findings to resource managers, policymakers, and the public to support sound management of biological resources and ecosystems in Alaska.

The Learning Room
Designed especially for mid-elementary-school-aged kids and up. Learn about all kinds of biologically related subjects.

Diversity and Abundance of Insects

Status and Trends of the Nation's Biological Resources
Summary of the status and trends of our nation's biological resources.

Nonindigenous Species
Discusses the issue of invasion by nonindigenous species.

Potential Effects of Global Change on Bats
Study on why bats are declining in population.

USGS Geology in Parks
Learn geology basics from touring the national parks.

Media for Science
Photo collections of maps, natural disasters, and activities at the USGS.

Monitoring Grizzly Bear Populations using DNA
Reports field methods and results of using DNA to monitor bear populations in the Glazier National Park.

Deserts: Geology and Resources
Describes various types of desert; including extraterrestrial deserts, illustrates various desert features and eolian (wind) processes, and discusses the use of remote sensing in studying deserts and the process of desertification.

Dinosaurs: Facts and Fiction
Do you ever ask "Where did dinosaurs live?" and "Why did dinosaurs grow so big?" Find out here and more!

South Florida Information Access
Provides geological and biological information for the South Florida region.

South Florida Virtual Tour
View beautiful habitat, plants, and animals of South Florida.

Cascades Volcano Observatory
Focuses on hazards, activity, history, and monitoring of volcanoes, with emphasis on volcanoes of the Western United States.

The Whooping Crane Report
Regularly updated reports on breeding whooping cranes.

Sea Birds Photo Gallery

View photos of sea birds.

Midcontinent Ecological Science Center
Contains articles on scientific researches and education pages for kids.

Links to Bat Web Sites

FrogWatch USA
Frogwatch USA is a frog-and-toad monitoring program for amateurs and scientists alike coordinated by the U.S. Geological Survey Biological Resources Division at the Patuxent Wildlife Research Center.

Northern Prairie Wildlife Research Center
Information for wildlife managers, scientists, and the public on natural-resource issues and biota of the North American Great Plains.

North American Reporting Center for Amphibian Malformations
Information on the issue of malformed amphibians, including a current map of the situation in the United States and Canada, and current literature and news articles.

What do the malformations of amphibians look like?
Photos that illustrate different types of abnormalities and malformations on amphibians, such as frogs and lizards.

Agate Fossil Beds
Produced by National Park Service's Division of Publication, this book provides a glimpse of that time, long before the arrival of man, when now-extinct creatures roamed the land which we know today as Nebraska.

House Bat Management
Describes batproofing techniques that will provide effective and acceptable alternatives for dealing with house bat problems and hazards.

An Introduction to Ants
Informative article on the ecology of ants.

Eastern Bluebird
Provides an introduction to the habitat requirements of the eastern bluebird and is designed to assist in the development of a comprehensive bluebird management plan.

North Dakota Prairie
A brief history of native prairie in North Dakota and information on programs and agencies concerned with its preservation.

Northeast Wetland Flora Field Office Guide to Plant Species
See illustrated glossary and more than 200 hundred species with detailed description and photos.

Southern Wetland Flora - Field Office Guide to Plant Species
Contains illustrated glossary and hundreds of detailed species descriptions with photographs.

Attracting Wildlife to Your Back Yard
A guide for homeowners who want to make their surroundings more attractive to wildlife.

Estimated Costs of Maintaining a Recovered Wolf Population
A cost comparison of maintaining a wolf population in Minnesota at levels.

Caterpillars of Eastern Forests
Includes species descriptions, life cycle and morphology information, and tips on photographing, rearing, collecting, and preserving specimens of many caterpillars living in forests of the eastern United States.

Caterpillars of Pacific Northwest Forests and Woodlands
A field guide to caterpillars commonly found in forests and woodlands of the Pacific Northwest, including sections describing the natural history, nomenclature, identification keys, and details for collection and preservation of specimens.

Grasslands
Features several animals and plants dependent on native grassland and provides insight into the relationship between remaining native grassland and biological resources.

Biological Control of Leafy Spurge
nformation on a major biological control program to combat the spread and reduce infestations of the aggressive, exotic perennial weed known as leafy spurge.

Macromoths of Northwest Forests and Woodlands
Informs on the moth's life cycle, species, and habitat. Includes photo of species.

Songbirds of North Dakota
Includes color photos, distributions and descriptive information on selected songbirds in North Dakota.

Butterflies of North America
Contains species photo gallery, information, and maps as to where butterflies appear.

Butterflies of North America
View over 500 photos of butterflies and species descriptions.

Moths of North America
Know more about moths, what they look like, where they live, and how they live.

Glossary of Bird Conservation Terms
Provide standard definitions for many of the terms used in avian conservation biology.

Snow Goose Population Problem
A three part series on the problems associated with overpopulation of snow geese in North America.

Western Wetland Flora
Field guide containing color photographs, line drawings, distinquishing features, range maps, and textual descriptions for 300 species of wetland plants that live in the western U.S.

Northern Prairie Biological Resources
List of information on the biotic resources of the Great Plains for decisionmakers, resource managers, scientists, and the public.

Assessing Breeding Populations of Ducks by Ground Counts
Methodology used to estimate annual abundance of breeding duck pairs on study areas in the prairie parklands and grasslands of southern Canada.

National Wildlife Health Center
Resource site for materials related to wildlife health research and the functions of the National Wildlife Health Center (NWHC).

West Nile Virus
Check out latest reports, preventions, and activity maps of West Nile Virus.

The Patuxent Plant List and Herbarium Collection
Its photo gallery contains a large collection of plants.

Birds of North America: Taxonomic List
List of birds by their family, species, and common names. Some listings link to an informative background page with pictures.

Amphibian Declines and Deformities
Links to researches on amphibian deformities and answers frequently asked questions on the issue.

From Microbes to Mammals - Invasive Species
Links to articles on various invasive species.

Hazards
Links to various hazards reports, including earthquake, volcanoes, flood, landslides, wildfire, wildlife diseases, geomagnetism, and coastal storms and tsunamis.

The Impact of Invasive Species on Reptiles and Amphibians
Links to researches about the issue of native amphibian and reptile populations worldwide under threat by exotic invasive species of plants and animals, including other reptiles and amphibians.

A Field Guide to the Reptiles and Amphibians of Coastal Southern California
Contains species photos, field guides, and illustrated glossary of amphibians and reptiles.

Western Ecological Research Center
Study of ecosystem, wildlife, and global change in Western U.S.

Invasive Species Research
Read reports on invasive plants and animals.

Sea Otter Research
Contains links to studies of sea otters.

Pintail Recovery Initiative
Follow pintail ducks' annual journey up and down the West Coast. Discover how biologists track the ducks, read their weekly journal, and track the ducks yourself using the interactive map.

The Rare Ones
Rare and endangered species

Park Geology Tour of National Parks
Learn geology through online tour of national parks.

Park Geology Teacher's Features
Teaching geology with national park examples.

Glacier National Park
Take an electronic field trip to the crown jewel of the Rockies.

The Fragile Fringe
Lesson plans and activities to teach students about wetlands.

The National Biological Information Infrastructure (NBII)
Use the NBII to answer a wide range of questions related to the management, use, or conservation of this Nation's biological resources.

More Than Skin Deep
A teacher's guide to caves.

GLOBE: Global Learning and Observations to Benefit the Environments Education Program
Teachers and students -- help scientists by sending your scientific data and observations to their data archive.

Bureau of Land Management
The Bureau of Land Management administers 264 million acres of public lands containing natural, historical, cultural, recreational, and economic resources.

FrogWeb: Amphibian Declines & Deformities
FrogWeb is a multiagency initiative that provides information about recent global declines and deformities among amphibian populations; presents efforts made by scientific agencies to study and address the phenomena.

Photo Gallery of Mount St. Helens
View over 190 photos of Mount St. Helens' landscape and wildlife before and after eruption.

Image Gallery from the U.S. Fish and Wildlife Service
Find images of fishes, wildlife, duck stamps, landscapes, and more.

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Maps and Images

Topographic . Geologic . Links

- Text adapted from USGS TerraServer and USGS Western Earth Surface Processes Page.

Whether on paper or on a computer screen, a map is the best tool available to catalog and view the arrangement of things on the Earth's surface. Maps of various kinds--road maps, political maps, land use maps, and maps of the world--serve many different purposes.

Topographic Maps

One of the most widely used of all maps is the topographic map. The feature that most distinguishes topographic maps from maps of other types is the use of contour lines to portray the shape and elevation of the land. Topographic maps render the three-dimensional ups and downs of the terrain on a two-dimensional surface.

Topographic maps usually portray both natural and manmade features. They show and name works of nature, including mountains, valleys, plains, lakes, rivers, and vegetation. They also identify the principal works of man, such as roads, boundaries, transmission lines, and major buildings.

The wide range of information provided by topographic maps makes them extremely useful to professional and recreational map users alike. Topographic maps are used for engineering, energy exploration, natural resource conservation, environmental management, public- works design, commercial and residential planning, and outdoor activities like hiking, camping, and fishing.

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- Adapted from COLLECTING ROCKS by Rachel M. Barker

Rocks Tell the Story of the Earth

The Earth is made of rock, from the tallest mountains to the floor of the deepest ocean. Thousands of different types of rocks and minerals have been found on Earth. Most rocks at the Earth's surface are formed from only eight elements (oxygen, silicon, aluminum, iron, magnesium, calcium, potassium, and sodium), but these elements are combined in a number of ways to make rocks that are very different.

Rocks are continually changing. Wind and water wear them down and carry bits of rock away; the tiny particles accumulate in a lake or ocean and harden into rock again. The oldest rock that has ever been found is more than 3.9 billion years old. The Earth itself is at least 4.5 billion years old, but rocks from the beginning of Earth's history have changed so much from their original form that they have become new kinds of rock. By studying how rocks form and change, scientists have built a solid understanding of the Earth we live on and its long history.

Rock-forming and rock-destroying processes have been active for billions of years. Today, in the Guadalupe Mountains of western Texas, one can stand on limestone, a sedimentary rock, that was a coral reef in a tropical sea about 250 million years ago. In Vermont's Green Mountains one can see schist, a metamorphic rock, that was once mud in a shallow sea. Half Dome in Yosemite Valley, Calif., which now stands nearly 8,800 feet above sea level, is composed of quartz monzonite, an igneous rock that solidified several thousand feet within the Earth. In a simple rock collection of a few dozen samples, one can capture an enormous sweep of the history of our planet and the processes that formed it.

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- Ecosystems
- Natural Resources

Types of Rocks

Geologists classify rocks in three groups, according to the major Earth processes that formed them. The three rock groups are igneous, sedimentary, and metamorphic rocks. Anyone who wishes to collect rocks should become familiar with the characteristics of these three rock groups. Knowing how a geologist classifies rocks is important if you want to transform a random group of rock specimens into a true collection.

Igneous Rocks | Sedimentary Rocks | Metamorphic Rocks

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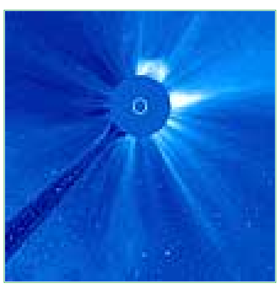
Real-time information helps to ensure that the critical information needed by emergency forecasters and managers during extreme events is available when it is most needed from the locations where it is needed.

Find out more about real-time information at the sites below:

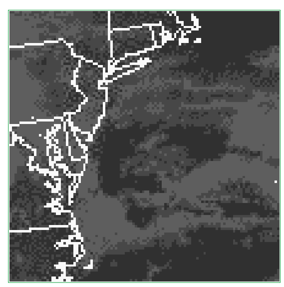
Link to USGS sites.
Link to non-USGS sites. We are happy to provide this link for your convenience. Please be aware that we cannot guarantee the accuracy of non-USGS sites.

Featured Sites



USGS Center for Natural Disaster Information
Provides real-time information about various hazards.

VolcanoCams Around the World
"Live" views of volcanoes from around the world, including Europe and Japan.



Geostationary Satellite Server
NOAA's real-time satellite weather images.

The Center for Integration of Natural Disaster Information
Provides real-time information about various hazards.

Earthquake Hazards Program
Provide and apply relevant earthquake science information and knowledge.

Geologic Information
Geologic and mineral resource surveys and mapping for the Department of the Interior.

Cascades Volcano Observatory
Focuses on hazards, activity, history, and monitoring of volcanoes, with emphasis on volcanoes of the Western United States.

Current Volcanic Activity
Contains a list of sites with real-time volcano monitoring.

VolcanoCams Around the World
"Live" views of volcanoes from around the world, including Europe and Japan.

Real-Time Water Data
Contains real-time information on streamflow.

USGS Water Resources Michigan
Michigan District operates Real-time monitoring networks and conducts scientific assessments and research of Michigan's water resources.

Johnson Creek Hydrologic Monitoring
Johnson Creek Hydrologic Monitoring

NOAA's Flood Threat Forecast
View most up-to-date information on national flood-threat forecast.

Windows to the Universe
Fun and intriguing site about the earth and space sciences.

Geostationary Satellite Server
NOAA's real-time satellite weather images.

USGS

TEXT VERSION

STUDENTS | TEACHERS | EXPLORERS

Explorers > Special Topics

- by Rob Dietz

An ecosystem is an area on the Earth that is a community of living organisms and their surrounding environment. Every person, animal, plant, rock, stream, and piece of land belongs to one or more ecosystems. For example, imagine an ecosystem made up of a freshwater pond that serves as a home for frogs, lily pads, fish, cattails, dragonflies, algae, and protozoa. Each of these organisms, along with its sources of food, sediments, nutrients, and the water itself, is a part of the pond ecosystem, which functions as a unit or a single community. Imagine, also, that this pond lies deep inside a forest. The pond and its inhabitants belong to the larger forest ecosystem, which also contains several rivers, other ponds, many kinds of wildlife, flowering plants, and (of course) trees. Ecosystems on Earth are incredibly diverse, both in size and in form–a large city that contains millions of people, their homes, and a built-up landscape is an urban ecosystem, while a small wildlife preserve within that city serves as a natural ecosystem.

Much like a person, an ecosystem has a given level of health. A healthy ecosystem performs many valuable functions, such as flood control, water purification, seed dispersal, pollination, pollutant removal, nutrient cycling, and habitat provision. These functions are beneficial to both humans and other inhabitants of ecosystems. Consider the value of one wetland ecosystem that helps remove toxic substances from drinking water, provides a nursery for baby fish, and supplies shelter for clams and mussels–and these are only a few of the services provided by this ecosystem. Many ecosystems experience the effects of disturbances. These disturbances can be caused by human actions, such as bulldozing a forest to build a highway, or they can be a result of natural events, such as soil erosion from heavy rains. Disturbances often decrease the ability of an ecosystem to provide valuable function, and thereby decrease the health of the ecosystem. A feature of ecosystems, from the smallest backyard to the entire globe, is that they tend to be resilient. Given time, ecosystems can often recover from disturbances, maintain their health, and continue to provide the functions necessary to sustain life on Earth.

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- Natural Resources

Explorers > Special Topics

- by Frances Pierce

Natural resources, such as coal and oil, are the key sources supporting the lifestyle of today. Coal provides the energy needed to generate more than half of our Nation's electricity. Coal resources are abundant and still relatively inexpensive. The USGS helps the Nation identify the cleanest coal to use in power plants. Oil is the source of gasoline used to power cars, trucks, and boats, as well as being a source of compounds that go into making plastics, synthetic materials, and even medicines. Natural gas is used to heat many homes. The USGS provides the Nation with estimates of how much oil and gas remain and where they might be found.

The development of energy resources provides jobs for many people and contributes to our Nation's economic health. Removing coal, oil, and natural gas from the Earth, however, can affect the environment. Therefore, scientists need to study ways to minimize the negative effects of developing and using energy resources.

Scientists also are investigating new sources of clean, abundant energy. Of all the fossil fuels in use today, natural gas, or methane, is the cleanest burning. Methane may be the fuel that helps our Nation make the transition to using hydrogen gas as an energy source by the second half of this century. Energy produced from hydrogen gas would not generate harmful pollutants or carbon dioxide, a greenhouse gas.


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7 8:32:53.3
8 8:33:03.7
9 8:33:18.8


11


Keep Washington Green
801

Eruptions of Mount St. Helens: Past, Present, and Future

Title Page

Geologic Information

VIEW a list of other USGS General Interest Publications

URL: <http://pubs.usgs.gov/publications/msh/>
Contact: Eastern Publications Group Web Team
Last updated: 06.19.97

USGS Fact Sheets (listed by Hazards Theme)

USGS activities in the hazards theme area deal with describing, documenting, and understanding natural hazards and their risks. These activities include long-term monitoring and forecasting, short-term prediction, real-time monitoring and communication with civil authorities and others during a crisis. Other significant activities are post-crisis analysis with scenario formulation to develop strategies to mitigate the impact of future events and preparation of coordinated risk assessments for regions vulnerable to natural hazards.

USGS Hazards Theme Home Page

General Hazards

- **FS2004-3060: Mapping a Flood...Before It Happens**
- **FS-069-03: Measuring Human-Induced Land Subsidence from Space**
- **FS-095-02: Vulnerability of U.S. National Parks to Sea-Level Rise and Coastal Change**
- **FS-052-02: WaterWatch—Maps and Graphs of Current Water Resources Conditions**
- **FS-050-02: USGS Environmental Studies of the World Trade Center Area, New York City, after September 11, 2001**
- **FS-103-01: Natural hazards on alluvial fans: The Venezuela Debris flow and flash flood disaster**
- **FS-165-00: Land Subsidence in the United States**
- **FS-150-00: Helping Coastal Communities at Risk from Tsunamis-The Role of**

U.S.Geological Survey Research

- **FS-141-00: Earthquakes and Tsunamis in Puerto Rico and the U.S. Virgin Islands**
- **FS-117-00: Mapping Buried Stream Valleys in Philadelphia, Pennsylvania"**
- **FS-093-99: Natural Hazards: Minimizing the Effects**
- **FS-188-97: Recent Highlights -- Hazards**
- **FS-177-97--html file: Reducing Risks from Geomagnetic Hazards--pdf file**
- **FS-248-96: Recent Highlights -- Hazards**
- **FS-244-96: Rapid-Estimation Method for Assessing Scour at Highway Bridges Based on Limited Site Data**
- **FS-061-95: Natural Hazards Program: Lessons Learned for Reducing Risk**

Volcano Hazards

- **FS-092-02: Mount Mazama and Crater Lake: Growth and Destruction of a Cascade Volcano**
- **FS-064-02: The Kamchatkan Volcanic Eruption Response Team (KVERT)**
- **FS-024-02: Red Mountain Volcano—A Spectacular and Unusual Cinder Cone in Northern Arizona**
- **FS-152-00:Viewing Lava Safely--Common Sense is Not enough**
- **FS-118-00: Historically Active Volcanoes in Alaska--A Quick Reference**
- **FS-060-00: Mount Hood--History and Hazards of Oregon's Most Recently Active Volcano**
- **FS-059-00: Mount Baker--Living With An Active Volcano**
- **FS-058-00: Glacier Peak--History and Hazards of a Cascade Volcano**
- **FS-036-00: Mount St. Helens--From the 1980 to 2000**
- **FS-027-00: Volcanic Ash Fall-A "Hard Rain" of Abrasive Particles**
- **FS-023-00: How Old is 'Cinder Cone'? -- Solving a Mystery in Lassen Volcanic Park, Californiapdf**
- **FS-132-98: Explosive Eruptions at Kilauea, Hawaii?**
- **FS-075-98: Can Another Great Volcanic Eruption Happen in Alaska? pdf**
- **FS-169-97: Volcanic Air Pollution--A Hazard in Hawaii**
- **FS-165-97: Living With Volcanic Risk in the Cascades**
- **FS-115-97: Benefits of Volcano Monitoring Far Outweigh the Costs--The Case of Mount Pinatubo--pdf**
- **FS-114-97: Lahars of Mount Pinatubo, Philippines pdf**

- **FS-113-97: The Cataclysmic 1991 Eruption of Mount Pinatubo, Philippines pdf**
- **FS-074-97: Living on Active Volcanoes--the Island of Hawaii**
- **FS-073-97: Future Eruptions in California's Long Valley Area--What's Likely?--pdf**
- **FS-070-97: Mount St. Helens -- From the 1980 Eruption to 1996:**
- **FS-064-97: Mobile Response Team Saves Lives in Volcano Crises--pdf**
- **FS-030-97: Volcanic Ash--Danger to Aircraft in the North Pacific--pdf**
- **FS-002-97: What are Volcano Hazards?--pdf**
- **FS-236-96: Detecting Debris Flows Using Ground Vibrations**
- **FS-172-96: Invisible CO2 Gas Killing Trees at Mammoth Mountain, California--pdf**
- **FS-108-96: Living With a Restless Caldera--Long Valley, California--pdf**

Earthquake Hazards

- **FS-096-03: Earthquakes—Rattling the Earth's Plumbing System**
- **FS-069-01: SCIGN.New Southern California GPS Network Advances the Study of Earthquakes**
- **FS-045-01: The Advanced National Seismic System: Management and Implementation**
- **FS-030-01: Did You Feel It? Community-Made Earthquake Shaking Maps**
- **FS-006-01: Earthquakes In and Near the Northeastern United States, 1638-1998**
- **FS-001-01: Earthquake Shaking -- Finding the "Hotspots"**
- **FS-103-00: 'Shake Maps' - Instant Maps of Earthquake Shaking**
- **FS-075-00: ANSS--Advanced National Seismic System**
- **FS-151-99: Progress Toward a Safer Future Since the 1989 Loma Prieta**
- **FS-152-99: Major Quake Likely to Strike Between 2000 and 2030**
- **FS-110-99--pdf: The "Larse" Project-Working Toward a Safer Future for Los Angeles**
- **FS-125-97--html file: Earthquake Information for the World --pdf file**
- **FS-103-97: Taking the Earth's Pulse --pdf**
- **FS-046-97--html file: Monitoring Earthquakes Across the United States --pdf file**
- **FS-200-96: Uncovering Hidden Hazards in the Mississippi Valley**
- **FS-183-96 Hazard Maps Help Save Lives and Property**
- **FS-105-96: Airborne Hunt for Faults in the Portland-Vancouver Area**
- **FS-096-96: Earthquake Technology Fights Crime**
- **FS-094-96: When Will the Next Great Quake Strike Northern California?**
- **FS-242-95: Quake Forecasting--An Emerging Capability**

- **FS-225-95: Southern Californians Cope With Earthquakes**
- **FS-224-95: Seismic Maps Foster Landmark Legislation**
- **FS-176-95: Saving Lives Through Better Design Standards**
- **FS-169-95: Pay a Little Now, or a Lot Later**
- **FS-168-95: The Mississippi Valley--"Whole Lotta Shakin' Goin' On"**
- **FS-167-95: Building Safer Structures**
- **FS-166-95: Utah Braces for the Future**
- **FS-111-95: Averting Surprises in the Pacific Northwest**
- **FS-097-95: Speeding Earthquake Disaster Relief**
- **FS-096-95: The Los Angeles Dam Story**

Landslide Hazards

- **FS-0071-00: Landslide Hazards**
- **FS-020-98: Popular Beach Disappears Underwater in Huge Coastal Landslide--Sleeping Bear Dunes, Michigan**
- **FS-013-98: Landslide Hazards in Glacial Lake Clays - Tully Valley, New York**
- **FS-176-97: Debris-Flow Hazards in the United States**
- **FS-159-96: Debris-Flow Hazards in the Blue Ridge of Virginia**

Flood Hazards

- **FS-037-02: The 1972 Black Hills-Rapid City Flood Revisited**
- **FS-104-01: Sparta, New Jersey, flood of August 11-14, 2000**
- **FS-041 -01: The 1951 Floods in Kansas Revisited**
- **FS-162-00: Floods in Cuyama Valley, California, February 1998**
- **FS-076-00: National Assessment of Coastal Vulnerability to Future Sea-Level Rise**
- **FS-064-00:Simulation of the Effects of Streambed-Management Practices on Flood Levels in Vermont**
- **FS-024-00: Significant Floods in the United States During the 20th Century--USGS Measures a Century of Floods**
- **FS-092-98: Passaic Flood Warning System**
- **FS-090-98: Somerset County Flood Information System**
- **FS-147-99: Floods in the Guadalupe and San Antonio River Basins in Texas, October 1998**

- **FS-244-96: Rapid-Estimation Method for Assessing Scour at Highway Bridges Based on Limited Site Data**
- **FS-229-96: The "100-Year Flood"**
- **FS-140-96: January 1996 Floods Deliver Large Loads of Nutrients and Sediment to the Chesapeake Bay**
- **FS-103-96: Statewide Floods in Pennsylvania, January 1996**
- **FS-089-96: Controlled-Flooding of the Colorado River in Grand Canyon: the Rationale and Data-Collection Planned**
- **FS-209-95: Stream Gaging and Flood Forecasting: A Partnership of the U.S. Geological Survey and the National Weather Service**
- **FS-062-95: Northern California Storms and Floods of January 1995**

Other Related Hazard Reports

Coastal Storms and Tsunamis

- **FS-026-00: El Niño Storms Erode Beaches on Monterey Bay, California**
- **FS-175-99: El Niño Sea-Level Rise Wreaks Havoc in California's San Francisco Bay Region**
- **Fact-Sheets: Briefings on Coastal and Marine Geology Projects**
- **Effects of Major Storms on Pacific Islands**
- **High-Energy Storms Shape Puerto Rico**
- **Louisiana's Barrier Islands: A Vanishing Resource**
- **Hurricane Impacts on the Coastal Environment**

Wildfires and Debris Flows

- **FS-036-03: Rapid-Deployment Data-Collection Networks for Wildland Fire Applications**
- **FS-018-00-pdf only: Fire ecology in the Southeastern United States**
- **FS-125-98: USGS Wildland Fire Research**
- **FS-112-95Debris-Flow Hazard in the San Francisco Region**

Biology Related Hazards

- **FS-154-00-pdf only: Chinese tallow: invading the southeastern Coastal Plain**
- **FS-020-00-pdf only: Nutria, eating Louisiana's coast**
- **FS-017-00-pdf only: Seagrasses in northern Gulf of Mexico: an ecosystem in trouble**

- **FS-016-00-pdf only: Restoring life to the dead zone: addressing gulf hypoxia, a national problem**
- **FS-096-97--pdf-only: Using remote sensing to monitor global change**
- **FS-095-97--pdf-only: Modeling hurricane effects on mangrove ecosystems**
- **FS-094-97--pdf-only: Predicting coastal flooding and wetland loss**
- **FS-093-97--pdf-only: Effects of climate change on southeastern forests**
- **FS-092-97--pdf-only: Salt tolerance of southern baldcypress**
- **FS-091-97--pdf-only: Global warming, sea-level rise, and coastal marsh survival**
- **FS-090-97--pdf-only: Global change and submerged aquatic vegetation research**
- **FS-089-97--pdf-only: Coastal wetlands and global change: overview**

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USGS

Information on Volcanoes

Volcano Frequently Asked Questions

- VOLCANO FAQs

General Interest Publications

Paper copies of the following general interest publications can be ordered from:

USGS Information Services
Box 25286
Denver, CO 80225

- **VOLCANIC AND SEISMIC HAZARDS ON THE ISLAND OF HAWAII**
  Explains the types of hazards posed by volcanoes, earthquakes and tsunamis on Hawaii; gives maps showing the probability of coverage by lava flows.
  Paper copy -- 48 p. Free
- **VOLCANIC HAZARDS AT MOUNT SHASTA, CALIFORNIA**
  Describes the kinds of volcanic activity that have occurred in the past, shows areas that could be affected in the future, and suggests ways of reducing the risks.
  Paper copy -- 21 p. Free
- **VOLCANOES**
  Describes the principal types of volcanoes, different types of eruptions, associated volcanic phenomena, their geologic settings, and how volcanoes are monitored. Explains how volcanic activity endangers and helps mankind.
  Paper copy -- 45 p. Free
- **VOLCANOES OF THE UNITED STATES**
  Describes the principal volcanoes in Hawaii, Alaska, and the Cascades Mountain Range that have erupted during the last few hundred years. Summarizes recent events at active calderas in California and Wyoming.
  Paper copy -- 44 p. Free
- **MONITORING ACTIVE VOLCANOES**
  Explains the need for monitoring volcanic areas in the United States and elsewhere. Describes techniques used to monitor eruptions at Mount St. Helens, Kilauea, and elsewhere.
  Paper copy -- 17 p. Free

Special Publications

Paper copies of the following publications can be ordered from the address above.

- **ERUPTION OF HAWAIIAN VOLCANOES -- PAST, PRESENT AND FUTURE**
  Paper copy -- 54 p.
- **ERUPTIONS OF MOUNT ST. HELENS -- PAST, PRESENT, AND FUTURE**
  Paper copy -- 46 p.

Selected References on Volcanoes

Other Volcano Information

Did You Feel It?
Volcanoes in the Learning Web
Other USGS Volcano Information
Smithsonian Institution-Global Volcanism Program
Volcano World

Return to Education and Outreach

This page is <URL:http://geology.er.usgs.gov/eastern/volcanoes/index.html>
MMaintained by Eastern Publications Group Web Team
Last updated 06.26.01 (krw)

Worldwide and U.S. Volcano Updates

- Weekly report of worldwide volcanic activity
- Current updates for U.S. and Russian volcanoes

Feature Stories

New Fact Sheet: The Alaska Volcano Observatory--Expanded Monitoring of Volcanoes Yields Results

A new fact sheet describes the increased volcano monitoring and eruption warning capabilities of the Alaska Volcano Observatory. Scientists have increased the number of volcanoes monitored with seismic networks from 4 in 1995 to 27 in early 2004. AVO also uses data and images from meteorological satellites to identify hot areas on volcanoes in Alaska and the Russian Far East and eruption clouds resulting from explosive activity.

AVO is a cooperative effort of the U.S. Geological Survey, the University of Alaska Fairbanks Geophysical Institute, and the Alaska Division of Geological and Geophysical Surveys. The observatory was founded in 1988 to monitor and minimize the effects of volcanic eruptions in Alaska.

What's New on USGS Volcano Web Sites?

Panorama images from crater rim of Pu`u `O`o vent, Kilauea Volcano

Near real-time images are now available from a camera (circle in photo) located on the north rim of the Pu`u `O`o crater. The images are refreshed every five minutes. The camera is for research and monitoring purposes and subject to sporadic breakdown, and its remote location makes immediate repair impossible. Be sure to check out the overall status of the Kilauea eruption to provide an overall context for what is happening at the volcano.

Predict an Eruption: Case Study from Kilauea and Mount St. Helens volcanoes

Try your hand at predicting an eruption of Mount St. Helens volcano using data collected by scientists of the USGS Cascades Volcano Observatory. This presentation uses data from several eruptive episodes of Mount St. Helens in the 1980's to show the way in which a series of eruptions were accurately predicted by USGS scientists as far as 3 weeks in advance. Go to Predict an Eruption.

Volcano Watch Current issue of Volcano Watch, a weekly essay written by USGS scientists from the Hawaiian Volcano Observatory.

U.S. Department of the Interior, U.S. Geological Survey, **Menlo Park, California**, USA
URL **http://volcanoes.usgs.gov/**
Contact: **VHP WWW Team**
| USGS Privacy Statement | USGS Disclaimer | Accessibility |
Last modification: 20 August 2004 (SRB)

ALASKA VOLCANO OBSERVATORY

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questions? AVO webmaster

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Photos of the "melt hole" on the summit of Mt. Spurr.
Chris Waythomas, August 2, 2004.

Click on an image to view the full-size picture.

Volcanoes with elevated level-of-concern color codes:
Last updated: Friday, August 13, 2004

Mount Spurr, Cook Inlet, Alaska, Level YELLOW
Details of recent activity.
Veniaminof Volcano, Alaska Peninsula, Alaska, Level YELLOW
Details of recent activity.
Shishaldin Volcano, Aleutian Islands, Alaska, Level YELLOW
Details on AVO updates page.

Bezymianny Volcano, Kamchatka Peninsula, Russia, Level YELLOW
Klyuchevskoy Volcano, Kamchatka Peninsula, Russia, Level YELLOW
Karymsky Volcano, Kamchatka Peninsula, Russia, Level YELLOW
Sheveluch Volcano, Kamchatka Peninsula, Russia, Level ORANGE
Details on KVERT updates page....

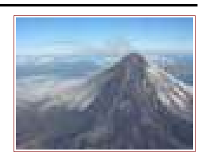
Map of Kamchatka Peninsula volcanoes

- What To Do If A Volcano Erupts
- Volcanic Ash, what it can do, and how to minimize the damage.

Kamchatkan-Aleutian Subduction Processes

- 4th International Seismic-Volcanic Workshop
- Second Circular (PDF)

CLEVELAND VOLCANO, Aleutian Islands



3 eruptions in February and March of 2001.

What's New: Images of Veniaminof Volcano

Products: Volcano hazard maps, Earthquake catalogs, USGS open file reports, AVO Bi-monthly reports and more!

About Us: Who we are and what we do.

Updates: Current and archived information releases on volcanic activity received from AVO and KVERT.

Status Reports: Daily Status Report received from AVO.

Atlas of Alaskan

Volcanoes: Use our interactive atlas to learn about the volcanoes of Alaska and Kamchatka.

TEXT ON

USGS science for a changing world
U.S. Geological Survey
Hawaiian Volcano Observatory

Kilauea
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- Eruption Summary
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Mauna Loa
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Volcanic Hazards
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About HVO
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- Volunteer program
- Location

Anatahan Volcano Update

A volcano update is being hosted by the Hawaiian Volcano Observatory in collaboration with the Emergency Management Office of the Commonwealth of the Northern Mariana Islands.

Live panorama images of Pu`u `O`o's crater

Do you want to see what is going on in the crater of Pu`u `O`o, Kilauea's erupting vent? Then check out the new panorama image from a camera (circled in both photographs) located on the north rim of Pu`u `O`o's crater. The images are refreshed every five minutes. You will always find a link to the panorama on the Kilauea update page. We caution you to view the panorama in the overall context of what is happening at Kilauea Volcano. We urge you to always refer to the Kilauea update when viewing the panorama.

The camera is subject to sporadic breakdown, and its remote location makes immediate repair impossible. Cameras can be where people should not. Pu`u `O`o is off-limits to the general public because of multiple and significant volcanic hazards.

Archive of previous feature stories

Photograph by C. Heliker
12 September 2003

Photograph by C. Heliker
3 October 2003

Top: Within minutes of erupting on the crater floor of Pu`u `O`o, lava drains back into the East Pond Vent and causes vigorous lava spattering as high as 10 m. The flow and drainback lasted only a few minutes. Such activity is probably caused by rising bubbles of gas that lift lava to the surface. The crust breaks, allowing gas to escape vigorously and drive brief spattering or a low fountain. When most of the gas has been lost, lava drains back into the vent. This activity is called gas pistoning. For full sequence of images, see September 2003 archive.

Bottom: Lava spattering from the west vent in West Gap Pit of Pu`u `O`o sails over a hornito on the rim of the pit, now filled with lava. Several flows spilled from the pit down the northwest flank of Pu`u `O`o, adding yet more lava to the west shield. The hornito and West Gap Pit were present before this most recent activity.

Archive of Featured Photographs

More Volcano Information from HVO and Beyond

Report a felt earthquake to HVO using this form.

Current issue of Volcano Watch essay, written weekly by USGS scientists.

Hawai`i Volcanoes National Park, home to HVO. Find visitor information and resources here.

More USGS Volcano Web sites

- Alaska Volcano Observatory
- Cascades Volcano Observatory
- Long Valley Observatory
- Yellowstone Volcano Observatory
- Volcano Hazards Program

Volcanoes for kids, from the Volcano World website.

U.S. Department of the Interior, U.S. Geological Survey, **Menlo Park, California**, USA
URL **http://hvo.wr.usgs.gov/index.html**
Contact: **hvowebmaster@usgs.gov**

Last modification: Monday, 02-Aug-2004 18:26:08 EDT (SRB)

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- Management Excellence
- Issues of Interest

How Do I? more
- Get a National Parks Pass?
- Trace Indian Ancestry?
- DOI Quick Facts

DOI manages 507 million acres of surface land, or about one-fifth of the land in the U.S.

- DOI en Español
- For DOI Employees
- DOI DC Operating Status

Select one

- DOI Jobs
- Teacher Resources
- Children's Pages
- Bureaus and Offices
- DOI Key Officials
- DOI History
- Webcams
- Old Faithful
- Mammoth Hot Springs
- Glacier National Park
- Grand Canyon
- Big Bend National Park

Since 2001, DOI has awarded more than $1.3 billion in grants to restore habitat for wildlife, protect endangered species, conserve water resources and remove noxious weeds.

$16 Million in Grants Awarded in 42 States
to Conserve Wildlife and Habitat

DENVER, Colo. -- Interior Secretary Gale Norton has announced $16 million in cost-share conservation grants to private landowners and Native American tribes. The grants will support 150 projects to conserve threatened, endangered and at-risk species and restore habitat across the country.

Norton announced the grants through three programs begun by President Bush - the Private Stewardship Grant program, the Tribal Landowner Incentive program, and the Tribal Wildlife Grant program. more

- Wildlife Grants Report

DOI Accomplishments

for Hunters and Anglers more

Your Interior Department

The Department of the Interior, comprising the eight bureaus listed at the right:

- Manages 1 out of every 5 acres of land in the US.
- Provides the resources for nearly one-third of the Nation's energy.
- Works with 562 federally recognized Indian Tribes.
- Administers U.S. responsibility to four overseas Territories.
- Provides water to 31 million citizens through 824 dams and reservoirs.
- Receives over 450 million visits each year to 388 units of the national park system, 544 wildlife refuges and vast areas of multiple use lands.

National Park Service

Secretary Norton celebrated the 88th anniversary of the founding of the National Park Service Wednesday by witnessing some of the maintenance projects recently completed, ongoing or planned in parks around the country. more

U.S. Fish and Wildlife Service

Over the past few years, FWS has worked to enhance hunting and fishing opportunities and to support the inherent values of conservation. more new

Bureau of Indian Affairs

Interior Secretary Norton has announced approval of gaming compact amendments signed in June by California Governor Arnold Schwarzenegger and five Native American tribes. more

Bureau of Reclamation

The Central Oregon Irrigation District has been awarded a Water 2025 Challenge Grant to assist in addressing long-term water needs in the Deschutes River basin. more

Minerals Management Service

A deep gas lease sale in the western Gulf of Mexico has drawn $171,387,285 in high bids. more

U.S. Geological Survey

USGS studies the impact of Hurricane Charley with before and after images. more

Bureau of Land Management

In remarks before the American Wildlife Conservation Partners in New York, Assistant Secretary Rebecca Watson highlighted the Bush administration's strong commitment to the health and conservation of wildlife and wildlife habitat in the land-use planning process for energy development. more

Office of Surface Mining

Old Faithful webcam is one of several webcams available in National Parks.

- Provides opportunities for hunters and anglers, working to improve habitat on millions of acres of public and private lands.

Below are links to some DOI sites that may be of interest.

Water
- Nez Perce Water Settlement
- Supply in the West
- Conservation
- Resources

Science
- Astrogeology at USGS
- Hurricanes
- Earthquakes
- Energy

Land
- Fire
- Maps
- Parks/Refuges/BLM Lands
- Offshore Lands/Volcanoes

Wildlife
- Endangered Species
- Habitats & Conservation
- Wildlife Refuge Centennial
- Duck Stamps

Communities
- Special Trustee
- Indian Trust
- Territories and Islands

InfoLinks
- www.HealthyForests.gov
- DOI Partnerships
- America's National Parks

Interior Secretary Gale Norton has announced a grant of $50,000 to assist Colorado in eliminating dangerous abandoned mine sites near the town of Crestone and the Great Sand Dunes National Park. more

Support Our Troops

Equal Opportunity Data Required to be Posted by the No FEAR Act

Recreation.gov | PRESERVE AMERICA | TAKE PRIDE IN AMERICA | LewisandClark200 | VOLUNTEER.GOV

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Website designed by NBC

U.S. Department of the Interior
1849 C Street, NW
Washington, DC 20240
webteam@ios.doi.gov

Last Updated on 08/26/04

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If you visit our site to read or download information, such as publications or press releases:

We collect and store only the following information about you: the name of the domain from which you access the Internet (for example, aol.com, if you are connecting from an America Online account, or princeton.edu if you are connecting from Princeton University's domain); the date and time you access our site; and the Internet address of the website from which you linked directly to our site.

We use the information we collect to measure the number of visitors to the different sections of our site, and to help us make our site more useful to visitors.

If you identify yourself by sending an E-mail:

If you send us personal identifying information by e-mail (for example, in a message containing a question or comment, or by filling out a form that e-mails us this information), we use it to respond to your requests. We may forward your e-mail to other Government employees or contract personnel who are better able to answer your questions. We do not keep or distribute lists of e-mail addresses to any parties outside of the USGS except as necessary to conduct official U.S. Government business. In no event, do we distribute lists of e-mail addresses to non-Government entities.

We want to be very clear: We will not obtain personally-identifying information about you when you visit our site, unless you choose to provide such information to us.

To Contact Us

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USGS FOIA Officer
Mail Stop 807
National Center
Reston, VA 20192

U.S. Department of the Interior, U.S. Geological Survey, Reston, VA, USA
URL http://www.usgs.gov/childprivacy.html
Contact: USGS Web Team
Last modification: 19-Aug-2002@07:35 (jaf)

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How we handle the information we gather when you visit our web site-

Web server activity logs

Like most web servers on the Internet, our servers collect and store all of the information that your web browser sends when it requests a web page, including:

- the name, domain, and numerical internet address of the "host" computer (typically a computer belonging to your Internet Service Provider and not your personal computer) from which you access the Internet;
- the date and time you accessed our site;
- the Internet address of the web page that you came from;
- the page you requested from our site and the number of characters sent to your computer; and
- the information your web browser software sends as its so-called "User Agent," which typically identifies the browser software and may also indicate the operating system and type of CPU used in your personal computer.

It is impossible to determine the actual identity of an individual user from this information.

The logs are periodically summarized and analyzed in order to study site usage over time and to perform other studies to help us improve the site's organization, performance, and usefulness.

Electronic mail

When you send us personal identifying information via e-mail (that is, in a message containing a question or comment, or by filling out a form that e-mails us this information), we use it to respond to your requests. We may forward your e-mail to other Government employees or contract personnel who are better able to answer your questions. We do not retain or distribute lists of e-mail addresses to any parties outside of the USGS except as necessary to conduct official U.S. Government business. In no event, do we distribute lists of e-mail addresses to non-Government entities.

File transfer protocol (FTP)

Many USGS sites using the file transfer protocol may also store your e-mail address if your web browser is configured to provide it. By default most web browser software does not send your e-mail address; this option is configured through your browser preferences. In Netscape Navigator, for example, this option must be set by you through the Advanced preferences category by the item labeled, "Send email address as anonymous FTP password."

Online surveys

When you voluntarily provide us with personal information as part of an online survey, we use it to perform various quantitative and qualitative analyses to improve customer service and satisfaction. We may forward the information collected to other Government employees or contract personnel to perform the actual analysis. You are under no obligation to participate in such surveys. Non-participation will not inhibit your use of our web site in any way. If you provided the information to us in error, you may request its removal at any time.

Ordering products

When you voluntarily provide us with personal information such as name, shipping and billing address, and credit card number when ordering products online, we use the information to fulfill your order. We may forward the information collected to other Government employees or contract personnel or to other computer systems (such as secure electronic commerce servers) to complete the requested transaction.

Marketing information

We may collect information from you, with your permission, that will allow us to provide various customer services, such as promotional materials and product availability notices. We may forward the information collected to other Government employees or contract personnel to provide specific marketing services. We will remove such information at your request.

Collection and release of gathered information

We want to make it clear that we will not obtain personal identifying information about you when you visit our web sites, unless you choose to provide such information to us. Except in the course of officially authorized law enforcement investigations, or in the event of a suspected attempt to deliberately circumvent our system's security with the intent to gain unauthorized access or to do physical damage (for example, an attack by hackers), we do not attempt to identify individual users or share any information we receive with any parties outside of the USGS. In the latter case, collected information associated with a suspected intruder might be shared through the USGS's Bureau Information Resources Security Administrator with an incident response service such as the CERT® Coordination Center.

Retention of collected information

Cookies - Some applications may save a "cookie" on your computer's hard disk to provide a temporary history of actions taken. A common example is the tracking of items placed in an online "shopping basket." We do not retain any record of "cookies" beyond what is necessary for running the application.

Web server activity logs - Monthly extracts of the log files are archived and stored off-line at our discretion for an indefinite period of time. Some statistical summaries derived from these data may be retained online or off-line at our discretion for an indefinite period of time.

E-mail - Information collected via e-mail will be retained at our discretion in a directly readable form for as long as necessary to complete our response. The e-mail itself may be retained in an archival form as required by Federal laws and regulations governing the retention of historical records of government agencies. For more information, please refer to the National Archives and Records Administration's Records Management Program.

Online surveys - Information collected via online surveys may be maintained at our discretion for an indefinite period of time.

Marketing information - Such information may be maintained at our discretion for an indefinite period of time.

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Freedom of Information

The USGS maintains a Freedom of Information Act (FOIA) Electronic Reading Room on the web that provides information on how to request USGS records and also provides links to Laws and Regulations governing USGS Activities and other information about the FOIA.

USGS FOIA Officer
Mail Stop 807
National Center
Reston, VA 20192

To Contact Us

If you have questions concerning the use of USGS materials, contact the Office of Communications.

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Last modified November 24, 2003.

U. S. Geological Survey

Freedom of Information Act

Electronic Reading Room

Background

The Freedom of Information Act (FOIA), 5 U.S.C. 552, as amended, is based on the principle of openness in government and generally provides that any person has a right, enforceable in court, of access to Federal agency records, except to the extent that such records (or portions thereof) are protected from disclosure by one of nine exemptions or by one of three special law enforcement record exclusions. Under the spirit and provisions of the FOIA, Federal agencies are to make their records available to the public to the greatest extent possible.

FOIA request for a copy of U. S. Geological Survey (USGS) records can be made by any individual or public or private organization other than a Federal agency. The request must: (1) be in writing, (2) specifically cite the Freedom of Information Act, (3) reasonably describe the records sought, and (4) indicate a willingness to pay fees, (specify the amount they are willing to pay) or ask for a fee waiver. The request will be sent to the USGS FOIA Officer, Mail Stop 807, National Center, Reston, VA 20192.

Process

Upon receipt, the FOIA Officer will direct the request to the appropriate USGS discipline FOIA Representative. The FOIA representative or an assigned action officer will respond to the request no later than 20 workdays after receipt, as required by the FOIA statute. When it is necessary to forward a request to another installation such as a field office for response, the time limit begins upon receipt by the field office. A time extension, not to exceed an additional 10 workdays, may be taken in certain circumstances. However, the requester must be notified in writing that an extension is being taken, the reason(s) for taking the extension, and the anticipated date of the FOIA response.

A FOIA response must advise the requester of the records that the bureau intends to disclose or to withhold, the exemption(s) authorizing the withholding (including a citation or summary of each exemption), and a strong justification for withholding the record(s). Normally the records to be disclosed will be provided with the response letter. If the records are not provided with the letter, they will be sent as soon as possible thereafter.

Denials

Headquarters USGS FOIA responses involving a denial or partial denial of records must be coordinated with the FOIA Officer. In the central, eastern and western regions, denials are usually signed by the Chief, Office of Regional Services, after consultation with the regional solicitor. A denial or partial denial letter will contain a paragraph advising the requester of the right to file an appeal with the Department of the Interior's FOIA Appeals Officer.

Department of the Interior's (DOI) Freedom of Information Act Handbook, 383 DM 15*

FOIA Search and Review Fees

Attorney General Ashcroft FOIA Memorandum, a new statement of Administration policy, issued October 12, 2001, to outline the new FOIA policy, located at the Department of the Interior FOIA web site.

List of USGS FOIA Contacts

Survey Manual 318.1 - Freedom of Information Act - General, provides USGS Guidance on the Freedom of Information Act.

USGS Organization Chart

USGS Electronic Directory

Laws and Regulations Governing USGS Activities

DOI Guide for Obtaining Information

DOI Frequently Requested Documents

U.S. Geological Survey Manual

Instructional Memoranda

About USGS

Department of Interior FOIA

Department of Justice FOIA

*Note: Download free Adobe Acrobat Reader to view PDF files at the Adobe web site. Or go to access.adobe.com for free tools that allow visually impaired users to read PDF files.

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U.S. Department of the Interior, U.S. Geological Survey
URL http://www.usgs.gov/foia/index.html
Contact: jcordyac@usgs.gov
Last modification: 21-Jun-2004@15:01

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If you cannot fully access the information on a particular page, please email the contact person, or group, named in the footer information at the bottom of the page and they will help you. This may include providing the information to you in an alternate format.

For further information and to learn more about the regulations governing the accessibility of Federal electronic information products, visit the Section 508 pages listed below:

- Section 508 home page - http://www.section508.gov/
- Access Board - http://www.access-board.gov/508.htm
- Web Accessibility Initiative (WAI) - http://www.w3.org/WAI/

Contact USGS

To Contact Us for Assistance or to Ask a Question

If you have a question or need assistance, you can contact us directly by calling toll-free 1-888-ASK-USGS (1-888-275-8747).

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Or you may use the form below to ask a question or send a message to the USGS:

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Subject	
Message*	
Please only click once! You will get a page in response.	Send message

* Required field. We need your email address to reply to you! See our [Privacy Statement](#).

To Locate USGS People

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To Locate USGS Facilities

The USGS operates offices and Science Centers in every state. To locate a facility near you go to USGS Offices and Science Centers.

the science center

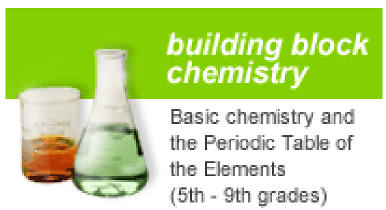
a teacher's guide to educational resources on the internet

the chlorine compound of the month

Cl Compound Archives go

August's Compound is
Aluminum Chloride: A "Can Do" Kind of Compound

Linky Chainsworth,
organic chemist



what's hot

Swimming Pool Germs Busted by Chlorine! (PDF)
Healthy Pool Coloring Book

Water Germs Busted By Chlorine! (PDF)
Coloring and Activity Book

teaching students about risk

Project Learning Tree: Teaches students *how* to think not *what* to think (K-12)

Science Education for Public Understanding: Teaches basic concepts of *environmental health risks* (9th and 10th grade)

Teachers: Join our listserv.
Enter your email address and click join.

join

Teachers: Join our listserv. Enter your email address and click join.

join

About the Science Center

The Science Center strives to provide teachers and students with resources that help improve the way scientific and environmental issues are discussed in the classroom. The Science Center features great lessons plans and classroom activities, provides educators with a Teacher Lounge where they can share information and discuss the latest issues, and provides users with a Gateway to other great educational resources on the Internet. If you have any questions or comments about this site, visit our feedback form and share them with us!

And now a word from our sponsor...

The Science Center is sponsored by the Chlorine Chemistry Council (CCC)TM and represents the latest effort by the CCC to help bring objective and balanced discussion of environmental and scientific issues to classrooms around the country. Working with premier education organizations like the Science Education for Public Understanding Program (SEPUP) and Project Learning Tree (PLT), the Chlorine Chemistry Council helps equip educators with the knowledge and tools needed to educate the country's students.

To learn more about the Chlorine Chemistry Council, check out the links below:

- About the Chlorine Chemistry Council
- Chlorine Chemistry Council Mission Statement

Teachers: Join our listserv. Enter your email address and click join.

join

Science Center Comments and Questions Form

If you have comments or questions and would like to contact the Science Center, please fill out the form below and we will respond to your request promptly. Fields with (*) are required.

Please note that you must be 13 years of age or older to submit information to this website.

First Name*		Last Name*	
Company		Address	
City		State	
Postal Code		Country	
Phone		Fax	
e-mail*			

Comments/Questions*:
(**Please note:** If you wish to receive free education materials, please click on the "free materials" link located at the top of each page within this website.)

SEND FORM | CLEAR FORM

*Order Free Materials**

To receive free materials from the Chlorine Chemistry Council®, simply fill out the form below. **You can request up to 10 copies of each item** that you would like to receive in the corresponding quantity box. When you have finished, simply scroll down to the bottom of the page or click on the "Fill out mailing info" link to fill out your mailing information.

Benefits Brochures

These easy-to-read, full-color brochures illustrate chlorine's beneficial role in our everyday lives with vivid text and photographs.

Quantity:
Fill out mailing info

Chlorine Cornerstone of Modern Medicine®
This brochure describes chlorine's important role in medical applications from acetaminophen to antibiotics, x-ray film to blood bags, and AIDS treatments to anti-cancer drugs.
(view this material online)

Quantity:
Fill out mailing info

Chlorine Vital to Public Safety®
This brochure highlights chlorine's role in manufacturing bullet-resistant "glass," bullet-resistant vests, protective helmets and face shields, seat belts and air bags.
(view this material online)

Quantity:
Fill out mailing info

Chlorine On the 'Front Line' In Hospitals
Not only is chlorine important in manufacturing pharmaceuticals, but it is also key throughout the hospital. This brochure reviews chlorine's importance in the latest diagnostic equipment and surgical techniques used in the nearly 6,500 U.S. hospitals.
(view this material online)

Additional Benefits Brochures

More information about chlorine and its benefits.

Quantity:
Fill out mailing info

Good Food Starts With a Clean Kitchen (poster)
This poster was developed to help ensure sanitary cleaning conditions in kitchens in order to protect food from airborne germs. The poster is dual-sided: one side is in English, the other side is in Spanish.
(view this material online)

Quantity:
Fill out mailing info

Use Safe Chemical Practices at Pools and Spas (poster)
A poster with basic information on safety practices when using swimming pool chemicals. The poster is intended for placement in the work areas of swimming pool care and maintenance professionals.
(view this material online)

Education Materials

CCC has produced a number of materials to reach educators and students in an effort to provide a more balanced perspective on chlorine issues.

Quantity:
Fill out mailing info

Chlorine Can Bring Chemistry to Life
This teachers' manual introduces educators and students to chemistry without tackling the whole periodic table of elements at once. The materials include chemistry background information, student activity sheets and a chlorine chemistry product tree.
(view this material online)

Quantity:
Fill out mailing info

Building Blocks of Our World: Chlorine (video)
This six-minute video shows the many uses of chlorine in everyday life.
(view this material online)

Free Online Materials

For your convenience, we offer a number of free, learning materials directly from our site. You can visit any of the materials below by clicking on the link provided.

Here's a Riddle
This 13-page booklet provides an overview of the following six brochures that highlight the different aspects of chlorine chemistry's societal benefits. An all-purpose, general tool to communicate several benefits of chlorine chemistry, the brochure also provides useful quotations from physicians and health officials on the significance of chlorine chemistry.
(view this material online)

Nothing Cleans Like Chlorine
One of the most effective and economical germ-killers, chlorine destroys and deactivates a wide range of dangerous germs in homes, hospitals, hotels, restaurants and water. This brochure illustrates chlorine's disinfectant role as one of the most important public health advances of the 20th century.
(view this material online)

Chlorine Enhancing Everyday Life
Many people are unaware of the many products made with the help of chlorine chemistry. From microprocessors and wires in computers to vinyl siding, windows and plumbing pipes in homes, this brochure depicts chlorine's diverse role in producing hundreds of products we rely on every day.
(view this material online)

Health Insight: A Consumer's Guide to Taking Charge of Health Information
This pamphlet will help you take charge of health information and educate yourself about health risks and opportunities to reduce risks.
(view this material online)

Chlorine's Contribution to National Security
The Chlorine Chemistry Council has designed a number of materials highlighting the many roles that chlorine plays in our lives and day-to-day activities. With the national spotlight focusing on security issues, it is important to understand the role chlorine plays in keeping our country safe. The materials provided here demonstrate that chlorine not only benefits our lives, it helps save them.
(view this material online)

Mailing Information

To receive the free materials you requested, please fill out all of the information below.

***Please note:** Only U.S. requests for materials will be fulfilled at this time. We ask that all non-U.S. visitors to this site access materials directly by clicking on the *"view this material online"* link provided after each description above.

First Name	
Last Name	
Company or Organization	
Address	
City	
State/Province	
Postal Code	
Country	USA
E-mail	

☑ Yes, subscribe me to your listserv so I can receive periodic email updates about chlorine chemistry!

[Send this form] [Clear this form]

If you have any comments or questions, please go to our Feedback Form. Thank you for your interest in the Chlorine Chemistry Council.

Teachers: Join our listserv. Enter your email address and click join.

join

CCC Materials

Chlorine Chemistry Quiz

Take our interactive quiz which will test your knowledge of chlorine and chlorine chemistry.

Building Block Chemistry

These lesson activities were designed to introduce students in grades 5 through 9 to basic chemistry and the periodic table. Students learn how chlorine and other elements combine to make products they use every day -- from soccer balls to tennis shoes, from televisions to vinyl siding.

Chlorine Experiments

These experiments are designed for a variety of grade levels and help demonstrate the properties and make-up of chlorine.

Gateway to Education

The Science Center is your gateway to other great educational resources on the web. Here you can see a list of websites that offer useful educational resource to teachers.

CCC and its Partners

About the Science Center

The Science Center strives to provide teachers and students with resources that help improve the way scientific and environmental issues are discussed in the classroom.

Science Education for Public Understanding Resources

With support from the CCC, the Science Education for Public Understanding Program (SEPUP) developed the Understanding Environmental Health Risks Module, which is designed to help students learn to think critically about the environment.

Project Learning Tree Resources

The CCC is proud to be a supporter of Project Learning Tree's latest module entitled Exploring Environmental Issues: Focus on Risk. This new high school curriculum allows students to explore the different aspects of environmental and human health risks that affect their daily lives.

Feedback

The Science Center would like your input on our website. Let us know of any questions and comments which we may be able to provide assistance.

The Science Center is sponsored by the Chlorine Chemistry Council. Created by The Bivings Group.

Teachers: Join our listserv. Enter your email address and click join.

join

Classroom

Below is a list of educational resources developed by the Chlorine Chemistry Council (CCC) and its partners. These modules and classroom activities are designed to help teachers discuss chemical elements and the environment in their classroom. If you are interested in getting additional information or have any questions or comments, click here.

- **Chlorine Compound of the Month**
  To help celebrate National Chemistry Week 2003, the Science Center launched a new feature, the Chlorine Compound of the Month. Every month a different chlorine compound is profiled-from its chemical composition to its practical uses. Quick side-bar lessons in basic chemical concepts accompany each write-up. Chemistry becomes fun through these short, colorful articles. The Chlorine Compound Archive will keep all previously published articles accessible. Teachers and home-schooling parents may wish to take advantage of follow-up questions and science activities for students.

- **Take a fun, interactive hospital tour**
  This interactive hospital tour features a mind-boggling array of products created by chlorine chemistry.

- **The Global Bug Conspiracy**
  The Global Bug Conspiracy invites kids to take a look at case files and rap sheets on potentially deadly microbes such as E. coli, giardia and shigella, and the bacteria that cause cholera and typhoid fever. The World Health Organization estimates that diseases associated with dirty water kill at least 6,000 people every single day.

- **The House That Chlorine Built**
  Did you know that many of the household items you rely on every day are products of chlorine chemistry? Do you realize that vinyl (as in "vinyl siding"), an increasingly popular sustainable construction material, is a product of chlorine chemistry? You might be surprised to discover just how many indispensable products found in a typical home have their origins in chlorine chemistry.

- **Building Block Chemistry**
  These lesson activities were designed to introduce students in grades 5 through 9 to basic chemistry and the periodic table. Students learn how chlorine and other elements combine to make products they use every day -- from soccer balls to tennis shoes, from televisions to vinyl siding.

- **Chlorine Experiments**
  These experiments are designed for a variety of grade levels and help demonstrate the properties and make-up of chlorine.

- **Science Education for Public Understanding Resources**
  With support from the CCC, the Science Education for Public Understanding Program (SEPUP) developed the Understanding Environmental Health Risks Module, which is designed to help students learn to think critically about the environment.

- **Project Learning Tree Resources**
  The CCC is currently working with Project Learning Tree on a new risk assessment module that will be available in the Fall of 1998. The module will follow PLT's successful format and help students define risk and learn the skills necessary to make wise decisions.

- **Chlorine Chemistry Quiz**
  Take our quiz which will test your knowledge of chlorine and chlorine chemistry.

Teachers: Join our listserv. Enter your email address and click join.

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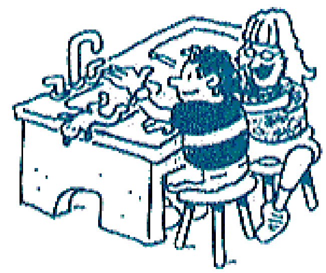
Chlorine Can Bring Chemistry to Life

Introduce students to chemistry without tackling the whole periodic table at once.

Recognizing basic elements as building blocks is essential to the study of science. And looking closer at one element in particular -- chlorine -- can help ignite students' interest in chemistry.



The following materials outline a two-day study of building block chemistry using basic concepts and easy-to-find materials. Additional free materials that can extend your lessons on chemicals in everyday life can be ordered by clicking here or by writing to Schools, Chlorine Chemistry Council, 1300 Wilson Blvd., Arlington, VA 22209.

- Science Scope Article Reprint: Chlorine and Building Block Chemistry
- Teacher Material: Chlorine Can Bring Chemistry to Life
- Student Sheet #1: Chlorine in our Lives
- Student Sheet #2: Exploring Chlorine Compounds
- Additional Activity: Eliminating Microorganisms from Water
- Background: A Common Building Block
- Background: Natural Chlorine? You Bet!
- Additional Teacher Background: Balanced Equations for Chloride Salt Activity

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PROJECT LEARNING TREE

Since 1973, Project Learning Tree (PLT) has reached more than 20 million students, and each year more than 30,000 teachers attend their workshops. Their goal is to help students learn how to think, not what to think about local and global environmental issues. A recent third-party evaluation of the PLT program has confirmed that it is effective in helping students become environmentally literate -- to understand basic science and, more importantly, to enable them to apply this knowledge in everyday life to make reasonable, well-thought out decisions.

PLT has an established network of workshops in every state that involves -- and is supported by -- classroom teachers, state boards of education, state and federal agencies, professional associations, and industry. PLT works with boards and departments of education in every state, providing you with an opportunity to reach key decision makers.

High School Risk Program

Together with many environmental, industry, and educational organizations, the CCC has supported PLT's development of a classroom curriculum for high school students that examines living with risk. The module provides students with a framework for applying scientific processes and higher order thinking skills to environmental issues. Students will learn to define and assess risk and the costs and benefits associated with various environmental policies and issues.

The module is designed to be infused into existing curriculum and is correlated to the national science standards. For more information, check out PLT's website!

SEPUP

Understanding Environmental Health Risks Module

With support from the CCC and the US Environmental Protection Agency, the Science Education for Public Understanding Program (SEPUP) developed the "Understanding Environmental Health Risks" module to help 9th and 10th grade students learn basic concepts associated with select environmental health risks.

Students are encouraged to look at the risks and benefits to individuals and communities of a variety of environmental topics such as drinking water safety, toxicology, and pesticide use.

Educators interested in ordering materials or learning more from this module are invited to visit the SEPUP website at http://www.sepup.com/

Teachers: Join our listserv. Enter your email address and click join.

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The Science Center is your gateway to other great educational resources on the web. Below is a list of other great web sites, sorted by general category. Check them out!

If you know of other educational resources that you think should be added to our links page, then fill out our Add A Link form and let us know.

Chemistry | Environment | General Science | Earth Science | Biology
Space and Astronomy | General | Publications | Museums | For Teachers

CHEMISTRY

- **Chemistry.org/kids** -- The American Chemical Society's site for kid-friendly chemistry activities, including National Chemistry Week.

- **Chem4Kids** -- Compiled by a division of the American Library Association, this easy to navigate site includes data on atoms, elements, matter, as well as biographies of famous chemists and will soon include chemistry quizzes.

- **Chemical Educational Foundation** -- The site is dedicated to serving the public interest as a primary national resource for conducting research and educational programs for proper distribution practices and the safe handling, use, storage, transportation, disposal, and recycling of chemical products.

- **TeachingPlastics.org** -- The American Plastics Council introduces the ultimate online scientific investigation resource for teachers and students. TeachingPlastics.org is a site that empowers teachers to introduce basic chemistry principles to students, while helping teachers accomplish some of the goals set by the NSES.

- **Web Elements** -- Maintained by Mark Winter, a professor at the University of Sheffield in England, Web Elements features an interactive periodic table which allows users to learn more about the elements.

ENVIRONMENT

- **Environmental News Network** -- The Environmental News Network is the premier source for science and environmental news on the Internet.

- **North American Association of Environmental Education** -- This site features a list of environmental education and classroom resources, as well as information about grants, obtaining funding, and conducting workshops.

- **Project Learning Tree** -- Like PLT itself, this web site is designed to help students gain awareness and knowledge of the natural and built environment, their place within it, as well as their responsibility for it.

GENERAL SCIENCE

- **National Science Teacher Association** -- This site contains message boards and on-line periodicals, as well as information about joining NSTA and NSTA's extensive resources.
- **Science Education for Public Understanding Program** -- SEPUP designs, develops and disseminates issue-oriented science education materials that promote scientific literacy and the use of evidence and tradeoffs in public decision-making.
- **Science Friday Kids Connection** -- Brought to you by National Public Radio

and Kidsnet, with funding from Toyota, the NEA, and others, this site provides background information and experiments on science issues which are in the news.

EARTH SCIENCE

- **Volcano World** -- This site allows users to learn about volcanoes around the world. Users learn what volcanoes are erupting and can take a virtual tour of volcanic craters.

BIOLOGY

- **Animal Network** -- This site contains listings and information on nearly every type of animal that can be used as a pet. It also contains caring and breed information for individuals in search of new pets.

- **A Guided Tour of the Visible Human** -- This site consists of some 9,000 digitized sections of the body. The site was compiled by the Children and Technology Committee of the Association for Library Service to Children, a division of the American Library Association.

- **Biotechnology Knowledge Center** -- A collection of documents about biotechnology and other life sciences.

SPACE AND ASTRONOMY

- **NASA** -- The NASA site contains the latest information about the U.S. space program. This general NASA site also links to other NASA sites on issues such as the MIR Space Station and the Mars Lunar Probe, as well as to the agency's many educational resources.
- **The Nine Planets** -- This site features photos and scientific information on the nine planets that make up our solar system. It was developed and is maintained by an individual named Bill Arnett.

GENERAL

- **Education World** -- Supported by the National Education Association, Education World strives to be the complete educator's resource guide to the internet. The site covers all academic disciplines and has on-line experiments, teacher forums, articles, etc.

- **Educational Resource Information Center (ERIC)** -- This site, supported by the U.S. department of Education and National Library of Education, is the world's largest database of educational materials. Teachers also can obtain answers to questions about educational research and practices from the AskERIC website.

- **E-mail Projects Homepage** --Allows learners and teachers to participate in E-mail projects in addition to providing educational projects.

- **Federal Resources for Educational Excellence (FREE)** -- This site contains hundreds of federally supported education resources placed on the site by more than 30 Federal agencies.

- **The Gateway** -- The Gateway provides the key to one-stop, any-stop access to high quality Internet lesson plans, curriculum units and other education resources.

- **BJ Pinchbeck's Homework Helper** -- This site gives students access to on-line resources for history, social studies, current events, foreign languages, math, and science.

- **Let's Go!: Around the World** --This site includes more than 500 pages that take students on "Great Learning Adventures" to the Amazon rain forest and Africa, and provides teachers with "Curriculum Connections" pages linking site content to the math, science and social studies curriculums.

- **Librarian's Guide to the Internet** --Helping librarians and other information seekers find resources and services on the Net.

- **The Study Web** --The Study Web features educational resources for teachers and students, including a search engine.

PUBLICATIONS

- ***Education Week*** --*Education Week* considers itself as the place on the World Wide Web for people interested in education reforms, schools, and the policies that guide them.

- ***Online Educator*** -- The *Online Educator* magazine site features extensive resources and links for bringing internet into the classroom. Updated weekly.

- ***New Scientist* Planet Science** -- The site contains articles from *New Scientist* magazine as well as an extensive collection of science news and resources.

- **Scientific American** -- The site contains articles from *Scientific American* magazine as well as an extensive collection of science news and resources.

- **Sci-Journal** -- Sci-Journal is an On-Line publication devoted to giving students the chance to publish works they've done in their school science classes.

- **TCWORLD** --A monthly On-Line publication for technology coordinators and school technology.

MUSEUMS

- **Children's Science Museum** --The site is a public science museum and a center for teacher education, research, and curriculum development at the University of California, Berkeley.

- **The Field Museum of Natural History** -- The Field Museum web site gives users an on-line preview of both permanent and temporary exhibits, and contains a special section which aids students and teachers visiting the actual museum in Chicago.

- **The Natural History Museum** -- This comprehensive site contains extensive scientific information on a variety of disciplines, as well as educational materials tailored specifically for students and teachers.

- **Smithsonian Institute** -- This huge site features general information about events and resources at the Smithsonian, and also contains links to all the museums that make up the Institute. Each museum has its own homepage and all the sites have great education materials.

FOR TEACHERS

- **The Catalyst** -- This site is aimed specifically at chemistry teachers and is a place for educators to share lesson plans and exchange ideas.

- **Community Learning Network** --This site is designed to help K-12 teachers integrate technology into their classrooms.

- **ED's Oasis** --ED's Oasis includes teacher support for classroom Internet use. Uses a set of research-based evaluation guidelines to pick the best web sites for classroom use.

- **Education Free Forum** -- The Education Free Forum is an On-Line collection of free materials available to educators on the web.

- **The Eduzone** -- Eduzone strives to provide educators with an Internet resource where all their classroom preparation and career development needs can be met.

- **Global School House** -- The Global School House is a site for students, teachers and parents to access educational resources and share information.
- **I Love Teaching** -- This On-Line resource is aimed at providing support to young teachers and those currently studying to be teachers.
- **The New Teacher Page** -- The New Teacher page offers resources and materials to people studying to be teachers or people who have just gotten into the classroom.
- **Teacher Talk Forum** -- This site provides learning resources for secondary students, their parents, and educators in addition to a forum for the discussions of issues important to these groups.
- **Teacher's Edition Online** -- This is a teacher resource that helps educators use technology in their classroom. The site also has great ideas about curriculum resources.
- **Teachers.net** -- Teachers.net features a large chat area on a variety of topics and also contains a variety of classroom resources and teacher support services.
- **Teachers Helping Teachers** -- Teachers Helping Teachers aims to provide young teachers with materials for their classroom and to give more experienced teachers a forum to share ideas and methods.
- **The Teacher's Network** -- The Teachers Network is a resource center for teachers and is run by Impact, with funding from large companies such as Exxon.

FOR STUDENTS

- **Homework Help** --Homework Help includes features to help students make the most of their study time and deal with other school related issues.
- **Student Web Pages** --This site includes a tutorial for students who want to publish educational projects on the web, with step by step directions for making personal pages.
- **Surfing the Net with Kids** --This site features Internet sites for kids reviewed, rated and organized by topic.

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The Science Center Bookstore

Welcome to the on-line Science Center Bookstore where science education is the theme of the day! Feel free to browse our shelves. Simply click on titles or book images for order information through Amazon.com.

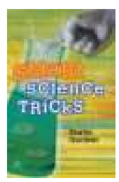
Microorganisms in Natural Water:

A World in a Drop of Water: Exploring With a Microscope
(Middle School)
by Alvin Silverstein, Virginia B. Silverstein

Water Treatment:

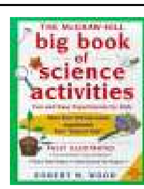
The Magic School Bus at the Waterworks
by Joanna Cole, Bruce Degen

Science Experiments Books:



Smart Science Tricks
by Martin Gardner

The Everything Kids' Science Experiments Book: Boil Ice, Float Water, Measure Gravity-Challenge the World Around You!
(Everything Kids Series)
by Tom Mark Robinson



The McGraw-Hill Big Book of Science Activities: Fun and Easy Experiments for Kids
(Science for Kids Series) - Kids, 8-12 years old
by Robert W. Wood

700 Science Experiments for Everyone
by Scientific and Cultural Organization. United Nations Educational, Unesco

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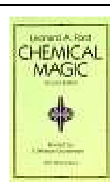
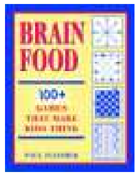


Chemical Magic, Second Edition
by Leonard A. Ford, revised by E. Winston Grundmeier (Designer)

Brain Teaser/Educational Game Books:



Brain Food: Games That Make Kids Think
by Paul Fleisher, Patricia A. Keeler (Illustrator)

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CHLORINE CHEMISTRY COUNCIL®
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Dell E. Perelman, Esq.
Vice President, General Counsel & Corporate Secretary
American Chemistry Council
1300 Wilson Boulevard
Arlington, VA 22209
Tele: (703) 741-5000
Fax: (703) 741-6000
E-Mail: copyright@americanchemistry.com

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(2) Identification of the copyrighted work claimed to have been infringed, or if multiple copyrighted works at a single online site are covered by a single notification, a representative list of such works at that site;

(3) Identification of the material that is claimed to be infringing or to be the subject of infringing activity and that is to be removed or access to which is to be disabled, and information reasonably sufficient to permit the service provider to locate the material;

(4) Information reasonably sufficient to permit the service provider to contact the complaining party, such as an address, telephone number, and, if available, an electronic mail address at which the complaining party may be contacted;

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This Agreement shall be governed by and construed in accordance with the laws of the Commonwealth of Virginia, United States of America. Actions brought under this Agreement shall be brought in the Commonwealth of Virginia in: (1) the Arlington Circuit Court (17th Circuit); (2) the Alexandria Circuit Court (18th Circuit); or (3) in the United States District Court for the Eastern District of Virginia in Alexandria, provided that federal jurisdictional requirements are satisfied. You agree and submit to the jurisdiction of such courts for the purpose of litigating any claim or action related to this Agreement.

SEVERABILITY AND INTEGRATION

Unless otherwise specified herein or expressly stated at Council Sites, the terms of this agreement constitute the entire agreement between you and the Council with respect to Council Sites and supersedes all prior or contemporaneous communications and proposals (whether oral, written, or electronic) between you and the Council with respect to Council Sites. If any part of these Terms & Conditions or terms specific to a Council Site is held invalid or unenforceable the remaining portions shall remain in full force and effect. The section titles in the Terms are for convenience only and have no legal or contractual effect.

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The Council reserves the right, in its sole discretion, to terminate your access to all Council Sites, a specific Council Site, or an area of a Council Site immediately and without notice. If you have any problems with these Terms & Conditions or with a Council Site your sole and exclusive remedy is to cease using the website(s).

SURVIVAL

In the event that your access terminates as provided herein or you cease using a Council Site(s), these Terms & Conditions shall survive.

CONTACT INFORMATION

If you have any questions regarding these Terms & Conditions, please contact us at info@c3.org. If you have any other questions regarding Council Sites, please contact us at:

Website Coordinator
Chlorine Chemistry Council
1300 Wilson Boulevard
Arlington, VA 22209
Tele: (703) 741-5000
Fax: (703) 741-6000
E-Mail: [info@c3.org]

LAST UPDATED

These Terms & Conditions were last updated on May 24, 2004.

**CHLORINE CHEMISTRY COUNCIL®
PRIVACY POLICY**

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THIS PRIVACY POLICY DISCLOSES HOW WE COLLECT, USE, SHARE, AND PROTECT INFORMATION GATHERED FROM PARTICIPATING COUNCIL SITES. BY USING THESE WEBSITES, YOU ARE AGREEING TO THE TERMS OF THIS PRIVACY POLICY, AS POSTED IN THIS AREA. IF YOU DO NOT AGREE WITH ANY TERMS OR PRACTICES DESCRIBED IN THIS PRIVACY POLICY, PLEASE DO NOT USE OUR WEBSITES. IN ADDITION, PLEASE REVIEW OUR TERMS & CONDITIONS, WHICH GOVERN YOUR USE OF OUR WEBSITES AND ANY DISPUTE ABOUT PRIVACY.

THE INFORMATION WE COLLECT

We may collect and store any information you enter on our websites or give to us in any other way. The type and amount of information the Council collects about you varies according to how you use Council Sites.

Collection of Personal Information

Many of the features on our websites are offered without collecting any Personal Information from you. "Personal Information" means personally identifiable information, such as your name, position, company, street address, telephone number, fax number, date of birth, e-mail address and other identifiers that permits physical or online identification of a specific individual. You can browse most of our websites and view much of our content on our websites anonymously.

There are certain Council Site(s) and features that require you to provide (voluntarily and at your option) certain Personal Information before you may participate in the website. For example, we collect Personal Information when you send us e-mail or otherwise contact us, enter a sweepstakes, register for off-line and online events, subscribe to a newsletter, or enroll or participate in chats and other online services.

When you make a purchase, or sign up for a paid service, we will also collect your credit card information as additional Personal Information. We will use credit card information only to complete the transactions you have requested.

Providing us with Personal Information is entirely optional and voluntary; however, if you do not provide the Personal Information requested, we may elect to not make the related service available for your use.

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We may also collect and store non-personally identifiable information about your visit whenever you interact with our websites. For example, we may automatically collect your domain name; IP address; means of entry to the site; the type of browser and operating system used to access the site; the date, time and duration of each visit; and the pages you visit.

USE OF COOKIES

Some of our websites may use "cookies" to enhance your experience. A cookie is a small file sent to your browser by a website's computer. Your Web browser places the "cookie" on your hard drive for record-keeping purposes and sometimes to track information about you. We use cookies to track site usage and to improve content and offerings. For example, we may use cookies to enable use of shopping carts or forms on our sites. Depending on the software browser you use, you may opt-out of the cookies delivered by our websites by changing the setting. Be aware that this will disable all cookies delivered to your browser, not just the ones that may be delivered by our websites.

HOW WE USE COLLECTED INFORMATION

We use information you provide about yourself collected through Council Sites to fulfill your request for our products, programs, or services; to respond to your comments and inquires; and to offer you other products, programs, or services that we believe may be of interest to you. For example, Personal Information may be used to communicate with you, such as to notify you when you have won one of our contests, to answer an inquiry, to fulfill a subscription request or product order, or to contact you about a user account with us.

Information from Other Sources

Personal Information you have provided may be used in combination with other information obtained through other means. For example, we may use your name, company, and e-mail address provided to us online in conjunction with our membership records in order to provide you with a user name and password to access a Council Site, forum, or specialized area. In other instances, an online inquiry about a purchase from us may prompt a review of an order placed by you over the telephone.

Information from Online Forums

The information collected in connection with our online forums is used to provide an interactive experience. This information is to facilitate participation in these online forums and communities and, from time to time, to offer you products, programs, or services. Note that online forums may be publicly accessible and other users may view information you post on them.

Use of Non-Personally Identifiable Information

Non-personally identifiable information, including information automatically gathered by our Web servers, is used to determine overall site traffic, popularity of areas of the site, what our users are looking for, and from where our users are linking to us. This information may also be used for aggregate statistical reporting, to improve the design and content of our sites, and to enable us to personalize your Internet experience.

WHO MAY USE COLLECTED INFORMATION

Information collected, whether personal or non-personal, may be shared within the Council, its parent, subsidiaries, and affiliated companies, and externally with third parties, such as members and business partners. However, it is our policy to not disclose externally with third parties personal information collected on our site, except in the following instances:

· The Personal Information provided to us may be transferred, disclosed, or shared with third parties to fulfill a request for our products, programs, or services and to those who may be engaged by us specifically to handle and deliver certain activities (e.g., sweepstakes) and perform other technical and processing functions, such as sending e-mail, fulfilling orders, or otherwise operating our sites. They have access to Personal Information needed to perform their functions, but may not use it for other purposes.

Information provided to us through correspondence may be shared (as appropriate) with other interested parties, including our members.

We may also disclose Personal Information to third parties (and our members) (1) when required by law or when the information is pertinent to judicial or government investigations or proceedings; (2) to protect and defend our rights and property; or (3) when necessary to protect our interests, our website(s), the safety of its users, or the public.

Other than as set forth above, we currently do not intend to share your Personal Information with third parties for other purposes. However, in the future we may disclose Personal Information you have provided to third parties for additional purposes. In the event we do, we will provide notices of such use to our users.

CHILDREN'S ONLINE PRIVACY PROTECTION ACT (COPPA)

We do not solicit or knowingly collect information from minors under the age of 13, in compliance with the Children's Online Privacy Protection Act (COPPA). For more information about COPPA, please visit: http://www.ftc.gov/ogc/coppa1.htm.

COLLECTION OF INFORMATION BY THIRD PARTIES, THIRD-PARTY SITES AND SPONSORS

Some of our sites may contain links to other sites. Other sites have their own information practices that may be different than ours. If you choose to use any of these links, you will be leaving our website and going to a third party (external) website. We encourage you to read the privacy policies at these external sites. We are not responsible for the privacy practices at these external sites or their use of any information they may collect from you.

In addition, you may have linked to one of our websites through another site. For example, in certain cases you may have linked to a sweepstakes or game site through banner or pop-up advertising on another site. In such cases the site you linked from may collect information from users who click on the banner or link. You may want to refer to the privacy policies on those sites to see how they collect and use this information.

Council Sites sometimes may offer content, contests, sweepstakes, or promotions that are sponsored by or co-sponsored with third parties. By virtue of their sponsorship, these third parties may obtain personally identifiable information that visitors voluntarily submit to participate in the contest, sweepstakes, or promotion. The Council has no control over the third-party sponsors' use of this information.

INFORMATION CORRECTION OR CHANGES

You have the ability to correct or change certain information in our records, such as your address and contact information. Generally, you may change this information at any time and as often as necessary. If you need assistance or have questions about correcting information, you can contact us via e-mail at info@c3.org.

E-Mails

If you have provided us with your e-mail address to subscribe to one of our services or to receive notifications or updates about one of the offerings at our sites and you wish to change your address or no longer wish to receive these communications, simply follow the unsubscribe instructions that appear in these e-mail communications.

Please note that any information that we have collected may remain in back-up storage, archival, and/or our log files, for some period of time after a deletion request. This may be the case even though no information about your account remains actively used as described in this Privacy Policy.

SECURITY

For certain Services, it may be necessary to collect payment to conclude the transaction. In such circumstances we use industry-standard secure socket layer (SSL) encryption. We do not sell or rent your personal financial information.

CONSENT TO TRANSFER

The Council reserves the right to sell or transfer your information provided to us to a third party entity in the event that the Council is acquired by or merged with another company or in connection with the potential sale or transfer of some or all of the business assets of our websites or the Council.

INTERNATIONAL USERS

Regardless of where you live or do business, by using Council Sites, you agree that we may collect, use, and transfer your information as described in this Privacy Policy.

NOTIFICATION OF CHANGES

Periodically we may make changes to this Policy. You are responsible for periodically checking our website for changes to this Privacy Policy. Your continued use of the site after these changes are posted constitutes your agreement to the changes with regard to any information collected.

CONTACT INFORMATION

We welcome your feedback regarding this Privacy Policy. If you have any comments, questions or concerns about this Privacy Policy you may contact us at:

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LAST UPDATED

This Privacy Policy was updated on May 24, 2004.

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Ministry of Water, Land & Air Protection

WILDFIRE-DAMAGED MARINE CAMPING SITES RE-OPENED

Minister of Water, Land and Air Protection Bill Barisoff, left, and BC Parks area supervisor Blake Dixon examine a section of burned firehose found during a July 29 trip to Okanagan Mountain Provincial Park. Barisoff visited the park to announce that six marine camping sites destroyed when wildfire swept through the park last summer, are now restored and open for use. Due to safety hazards created by the fire, the rest of the park remains closed. [View news release]

Minister's Photo Gallery

Latest News

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August 26, 2004
$13.5 MILLION TO RE-BUILD MYRA CANYON TRESTLES

KELOWNA Reconstruction of the historic Myra Canyon trestles destroyed by wildfire will begin this fall thanks to a $13.5-million partnership between the provincial and federal governments, Premier Gordon Campbell and Senator Ross Fitzpatrick announced.

Read more >>

August 18, 2004
FISHING REGULATIONS TO PROTECT TROUT STOCKS

The ministry's vision is a clean, healthy and naturally diverse environment that enriches people's lives, now and in the future.

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- MacMillan Park Safety Improvement Project Fact Sheet

PENTICTON - New fishing regulations have been implemented in several waters in the Kettle River Basin to rebuild trout populations and improve angling quality.

Read more >>

August 12, 2004
HORSEFLY RIVER OPEN AGAIN FOR SPORT FISHING

WILLIAMS LAKE ? Cooling water temperatures have prompted the Ministry of Water, Land and Air Protection to re-open sport fishing on the Horsefly River. The decision, which takes effect August 13, 2004, affects the Horsefly River downstream from Woodjam Creek.

Read more >>

August 11, 2004
PRESCRIBED BURN TO REDUCE MOUNT ROBSON WILDFIRE RISK

PRINCE GEORGE   A prescribed burn in Mount Robson Provincial Park will reduce wildfire risk and address the pine beetle infestation, Prince George-Mount Robson MLA Shirley Bond and Water, Land and Air Protection Minister Bill Barisoff announced.

Read more >>

July 29, 2004
WILDFIRE-DAMAGED MARINE CAMPING SITES RE-OPENED

KELOWNA   Six marine camping sites damaged by a wildfire last year in Okanagan Mountain Provincial Park have now re-opened, Water, Land and Air Protection Minister Bill Barisoff announced.

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NORTHERN MEDICAL PROGRAM OPENS AT UNBC

Premier Campbell helped open the new Northern Health Sciences Centre at UNBC, where new doctors will train to provide quality health care in northern communities.

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August 27, 2004
NEW "SPIRIT OF 2010 TRAIL" LAUNCHED TO ENHANCE TOURISM

PENTICTON   The Province and community partners will invest $4.2 million to launch a new Spirit of 2010 Trail network that will link 18 B.C. communities, announced Premier Gordon Campbell and the Honourable Stephen Owen, Minister of Western Economic Diversification and Minister of State (Sport).

[Read more >>]

August 26, 2004
$13.5 MILLION TO RE-BUILD MYRA CANYON TRESTLES

KELOWNA   Reconstruction of the historic Myra Canyon trestles destroyed by wildfire will begin this fall thanks to a $13.5-million partnership between the provincial and federal governments, Premier Gordon Campbell and Senator Ross Fitzpatrick announced.

[Read more >>]

August 23, 2004
TOURISM, HOSPITALITY CENTRES TO HELP PREPARE FOR 2010

Key Initiatives

SPIRIT of 2010 British Columbia. Be Here.

ACHIEVE BC BRINGING OUT THE BEST

Explore Your Parks

Discover B.C. this summer

Help Prevent Forest Fires

West Nile Virus

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VANCOUVER - Government has developed a new consortium to lead tourism and hospitality training initiatives to help prepare B.C. to host events like the 2010 Winter Games.

Read more >>

August 20, 2004
NEW LOAN REDUCTION PROGRAM TO ASSIST STUDENTS IN NEED

VICTORIA - Government has established a new loan reduction program to help high-needs students manage the costs of post-secondary education, Advanced Education Minister Shirley Bond announced today.

Read more >>

August 17, 2004
FIRST-EVER NORTHERN MEDICAL PROGRAM NOW OPEN

PRINCE GEORGE - The new northern medical program facility is now open, and for the first time medical students will be trained in the north to serve northern and rural communities, said Premier Gordon Campbell.

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Did you know?

While forestry, mining, fishing and agriculture remain important to B.C.'s economy, there is strong growth in new industries such as eco-tourism, agri-tourism, film and high tech.

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Printer Version

Honourable Bill Barisoff

Bill Barisoff was appointed Minister of Water, Land and Air Protection on Jan. 26, 2004. He previously served as Minister of Provincial Revenue.

Mr. Barisoff previously held a variety of critic roles for the Official Opposition, including agriculture, transportation and highways and aboriginal affairs. He served on the province's Motor Carrier Commission and was a member of the Select Standing Committees on Aboriginal Affairs and on Agriculture.

He was first elected in 1996 to represent the riding of Okanagan-Boundary and was re-elected in 2001 for Penticton-Okanagan Valley.

Mr. Barisoff, who was born and raised in Oliver, owned a trucking firm before his election to the Legislative Assembly.

He served as a school trustee for 18 years, including eight as chair of the Southern Okanagan school board; was a volunteer firefighter in Oliver for over 25 years; and sat on the Okanagan Labour Relations Council. He was also chair of the Oliver Recreation Commission for one year.

Bill and Edna Barisoff live in Oliver and have three sons: Glen, Michael and Darren.

Honourable Bill Barisoff
Minister of Water, Land and Air Protection

Contact Information

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  250 387-1187
- **Fax**:
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  STN PROV GOVT
  Victoria BC
  V8W 9E2

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Emergency Contacts:

Environmental Emergencies: 1-800-663-3456.

Environmental emergencies include hazardous or toxic spills, discharges, emissions, as well as dyke and dam failures, debris flows and floods.

Conservation Officer Service: 1-800-663-9453 (WILD)

People having problems with bears, cougars, wolves, or other predators should call the conservation officer service immediately. Dangerous wildlife should never be approached.

Ministry Office

The Ministry of Water, Land and Air Protection mailing address is:

PO Box 9339 Stn Prov Govt
Victoria BC
V8W 9M1

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Fax: 250 387-5669
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Fax: 250 387-1356

E-mail: WLAP.Minister@gems9.gov.bc.ca

Deputy Minister's Office

Gord Macatee
Deputy Minister
Telephone: 250 387-5429

Communications Branch

For Media Enquiries, please contact:

Max Cleeveley
Communications Director
Telephone: 250 387-9973
Fax: 250 356-6464

Other Branches or Divisions

Staff in local ministry offices can assist with inquiries. Office addresses and phone numbers are available on-line, see the following:

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Vendor Complaint Process

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Water Resource Information

NEW Mackenzie River Basin State of the Aquatic Ecosystem

The Mackenzie River Basin State of the Aquatic Ecosystem Report (SOAER) is a report prepared by the Mackenzie River Basin Board to inform decision-makers about the aquatic health and biodiversity of the major rivers found within the Mackenzie River basin. The report is also intended to identify gaps in current ecological knowledge, both scientific and traditional.

Aquifer Awareness (Funding) Program for BC Communities, 2003-4

The Aquifer Awareness Program will contribute up to $1,000 to eligible British Columbia communities, so they can set up "ground water protection zone" signs at entry points to important aquifers used for drinking water. The deadline for receipt of applications for funding is February 1, 2004.

MTBE (Methyl Tertiary-Butyl Ether) Factsheet

MTBE in gasoline improves air quality by reducing benzene and carbon monoxide emissions, but if spilled or leaked, it can contaminate our valuable ground water supplies.

Ambient Water Quality Guidelines for Methyl Tertiary-Butyl Ether (MTBE)

This report is one in a series that establishes ambient water quality

- River Forecast Centre
- State of Environment Reports
- Snow Surveys
- Water and Air Monitoring and Reporting Section
- Water Information Section
- Water Licences: Find Them
- Water Rights Information
- Water Quality
- Water Surveys
- Water Use Planning
- Water Utilities
- Water Wells Query Database
- Wetlands in BC

Other Links

- Water, Air and Climate Change Branch
- Freshwater Information (Environment Canada)
- Fisheries and Oceans Canada
- Land and Resource Registries Portal
- BC River Data Current Conditions

Contact Us

Webmaster
Ministry of Water,
Land and Air Protection;
Government of British Columbia

PO Box 9340,
Stn Prov Govt
Victoria BC
V8W 9M1

guidelines for British Columbia. It sets guidelines for MTBE to protect drinking water, freshwater and marine aquatic life, recreation, and livestock watering.

Report on MTBE Sampling Survey

This is a preliminary survey of MTBE in ground water at selected well sites in British Columbia.

· Top

Freshwater Strategy for BC

A Freshwater Strategy for British Columbia, Nov. 1999

Progress Report on the Freshwater Strategy, March 2000

Water Conservation and Water Use

Water Conservation Strategy for British Columbia

Water-Use Efficiency Catalogue for British Columbia

BC Auditor General's Report

Auditor General's Report, 1998/1999:
Report 5: Protecting Drinking-Water Sources

Second Report (Nov. 2000): Information provided to the Select Standing Committee on Public Accounts about the follow-up of recommendations in the 1998/1999 Report 5: *Protecting Drinking-Water Sources*.

Tahtsa Narrows Dredging Review

This website is about Alcan Inc.'s proposal to dredge Tahtsa Narrows in the Nechako Reservoir in northwestern BC. Federal and provincial government agencies have developed a coordinated process for review of Alcan's proposal. The process is detailed in 20 steps with an overview document as well. The coordinated Federal/Provincial Process is available here.

Nechako Environmental Enhancement Fund (NEEF)

In 1997, the Province of British Columbia and Alcan signed an agreement to settle the outstanding legal issues related to the rejection of the Kemano Completion Project. The agreement provides for the Nechako Environmental Enhancement Fund.

Our vision is a sustained and healthy water resource.

Street Address:
2975 Jutland Rd
Victoria BC

BC Government Directory

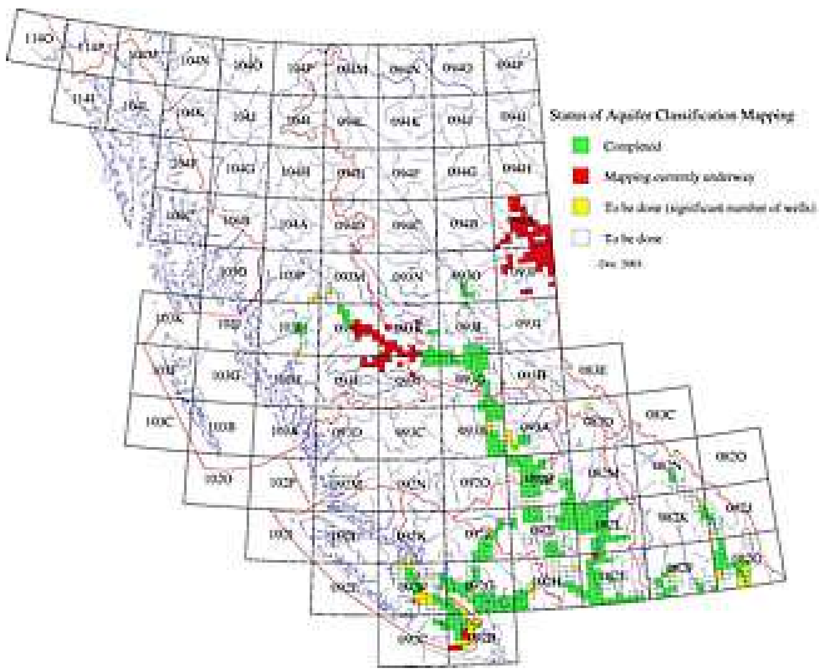
Aquifers in British Columbia

Query the Aquifer Database / View the Aquifer Image Portfolio
Aquifers and Water Wells in BC /
NEW Guide to Using the BC Aquifer Classification Maps / for the Protection and Management of Ground Water

Ground water provides 23 percent of the Province's population with drinking water, comprises 9 percent of total water consumption in the Province and represents 25 percent of the ground water use in the nation (Hess, 1986). It has been recognized for a number of years that a greater understanding of the existence and characteristics of aquifers in British Columbia is essential. The 1993 discussion paper *Stewardship of the Water of British Columbia* proposed that a program for classifying and mapping aquifers in ground water management areas be initiated.

Status of Aquifer Classification Mapping

(Click map for larger view.)

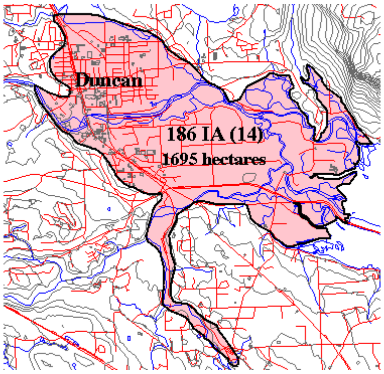


In 1994, a map based Aquifer Classification System was developed for the Ministry of Environment, Lands and Parks "Water Management Program" to identify, map and categorize aquifers using data from the provincial water well database. The objective of this aquifer classification system is to inventory and prioritize aquifers for planning, management and protection of the Province's ground water resource. To date, over 600 aquifers have been delineated. Individual aquifers in the format as shown by the example of the Duncan Aquifer to the lower left are displayed through a query of the aquifer image portfolio.

If you have ArcInfo capability this is the FTP link to digitized aquifer polygons in ArcInfo export format.

Example of an Aquifer at Duncan, BC

(Click map for larger view.)



Classifying aquifers in our Province is of vital importance. In some areas ground water is the only viable and economic source of water supply for individual and community water supply systems as well as augmenting agricultural and industrial uses. Ground water often maintains base flows in rivers and streams during periods of drought and is critical to fisheries habitat and spawning areas. With increasing demand and reliance on ground water from a growing population comes the need to increase efforts to protect and manage the resource.

Aquifer classification mapping provides an appropriate tool for optimizing water resources decisions affecting use and resource protection. There is more information on the BC Aquifer Classification System by Berardinucci and Ronneseth (2002), and Kreye et al, (1994) in the Reports section of this home page.

Aquifers and Water Wells in BC

This interface to ground water aquifers and water well locations is under development and now replaces other methods of delivering ground water data to the public, consultants and water well drillers.

Hard copies of water well location mapping are no longer available as this service has been replaced by Aquifers and Water Wells in BC .

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Aquifers and Water Wells of British Columbia

This site displays groundwater management information for the Province of British Columbia. It contains aquifer and water well maps and data that are currently under review for completeness and accuracy, so therefore the information displayed on this site should not be relied upon for decision making use of any kind.

View the Map

For further information about groundwater management in British Columbia, please visit the Groundwater Information Site.

Water Well Data Output

Aquifers and Water Wells in BC

This interface to groundwater aquifers and water well locations is under development and now replaces other methods of delivering groundwater data to the public, consultants and water well drillers. You may still use the following older search methodologies if you wish. Hard copies of water well location mapping are no longer available as this service has been replaced by Aquifers and Water Wells in BC .

Type in the search criteria, select the output columns and click on Search.
Well Query Help Notes. It always pays to read the directions.

Search Criteria:

☐ **Well Tag Number:**

☐ Street Name:

☐ Land District:

☐ Site Area:

☐ Range:

☐ Township:

☐ Observation Well Number:

☐ District Lot:

☐ BCGS Mapsheet:

☐ Section:

☐ Choose by Island:

☐ Lot:

☐ Plan:

Sort by: BCGS Mapsheet

Show # of Wells Found ☐

Data Output/Export: Display on the screen as a table

Browser supports tables: Yes

Search | Erase

When you have entered your data request, please click on the '**Search**' button adjacent to the entry box.

Help on using this screen.

BCGS grid help: detailed grid.

Search by well tag number. This search returns a **detailed** record for a particular well in a format developed in conjunction with the British Columbia Ground Water Association. For example 000000044593.

Well Tag Number [0000000] [Search] [Erase]

USE CAPITALS FOR ALL THE FOLLOWING SEARCHES!

Summary Search by British Columbia Geographic System Grid. This search returns a summary of water wells in that particular geographic area. (For example entering 092G024414 returns a summary of water wells on a portion of the University of British Columbia campus.)

BCGS Number [ ] [Search] [Erase]

Lithology Summary by British Columbia Geographic System Grid. This search returns lithologies of water wells in that particular geographic area. (For example entering 092G024414 returns lithologies of water wells on a portion of the University of British Columbia campus.)

BCGS Number [ ] [Search] [Erase]

Search by Street Name**USE ALL CAPITALS**

Street Name [ ] and BCGS Mapsheet [%] [Search] [Erase]

Search by **BCGS reference and well number**.

BCGS Reference (like 092G024414) [ ] Well Number (like 2) [ ] [Search] [Erase]

If your search returns saying NO ROWS SELECTED then no record was found matching the description you gave. The searches by legal land description or street name may not always be successful in finding a well due to defeciencies in data as provided. The legal descriptions in the water well database are the legal descriptions of the property at the time the water well was constructed. If your search is unsuccessful in finding a particular well these ways; you may find it with a BCGS (British Columbia Geographic System) search. If you cannot find the well with a BCGS search; then, that record has not been provided to the Groundwater Section by the Owner or Driller or is a recent record which has not yet been processed.

Please note -- This database is updated at the first of every month

Older and Specialized Searches.

Specialized Output for mapping comparisons. Helpful when you are trying to reconcile well numbers from some of the older water well location maps.Search by BCGS.

Search by well tag number. This search returns a **detailed water well record** for a particular well including the lithology of the water well.

Search by well tag number. This search returns lithology information for a particular well.

Lithology output for Aquifer Vulnerability Studies Search by BCGS.

Lithology output for Aquifer Vulnerability Studies Search by BCGS. Stripped output format.

More Lithology output for Aquifer Vulnerability Studies Search by BCGS and Sequence Number.

Specialized Output for Aquifer Classification Studies Search by BCGS.

Information Disclaimer

The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments. The information in this database is not to be used for solictation purposes.

Last updated: December 12, 2002

BRITISH COLUMBIA

REGISTER

of **Qualified Well Drillers** in the Province of British Columbia

****

Pursuant to Section 2 of the ***Ground Water Protection Regulation*,** the Comptroller must establish and maintain a register of qualified well drillers who are authorized to operate in British Columbia. The list of qualified well drillers whose names are in the Register, must be made readily available to the public during normal business hours, or be available in electronic form on the internet. A person wishing to be recognized as a qualified well driller in British Columbia and wanting to be listed in the Register may apply to the Comptroller pursuant to Section 3 of the ***Ground Water Protection Regulation.***

****

Well Driller ID #	Name	Company Name	Company Address	Company Phone #	Company Fax #	Company E-Mail Address	Class of Well Driller*	Date of Registration

* The Register may list qualified well drillers as belonging to a particular class of qualified well driller.

The Comptroller **may remove from the Register** of qualified well drillers any person who:

- fails to meet all of the necessary requirements for registration,
- is no longer actively working in British Columbia as a qualified well driller, or
- is deceased.

A person listed as a qualified well driller in this Register **must advise** the Comptroller in writing **within 60 days of any changes** to the information included in the Register or if they are no longer actively working in British Columbia as a qualified well driller.

By listing persons as qualified well drillers in this Register, the Province of British Columbia in no way guarantees, or may be held liable, for any work performed by the person.

The order in which persons appear in this Register is by date of registration and in no way reflects any order of preference, special favour or any other bias on behalf of the Province of British Columbia.

The person whose name appears in this Register should, in the course of their duties as a qualified well driller in British Columbia, **carry with them the well driller identification card** issued to them by the Comptroller and must **present it upon request** to the Comptroller, the Regional Water Manager, an engineer or an officer under the *Water Act* , or a Drinking Water Officer under the *Drinking Water Protection Act,* as proof of their qualifications as a well driller pursuant to Section 71 of the *Water Act*.

APPLICATION FOR REGISTRATION

As a **Qualified Well Driller**
in the Province of British Columbia

****

Pursuant to Section 3 of the ***Ground Water Protection Regulation*** a person may apply to the Deputy Comptroller of Ground Water for registration as a **qualified well driller** in the Province of British Columbia. The applicant for registration **must provide proof that the applicant is at least 19** years of age and **one of the following** with the application:

- **(i)** documented evidence (e.g. letter(s) and reference) from employer(s) of having a minimum of 5 years full time experience drilling wells in British Columbia or in another jurisdiction;
- **(ii)** the original or a notarized copy of a Certificate of Qualification as a Water Well Driller issued by the Province of British Columbia and documented evidence of having a minimum of 3 years full time experience drilling wells;
- **(iii)** the original or a notarized copy of a certificate as a Ground Water Drilling Technician issued by the Canadian Ground Water Association and documented evidence of having a minimum of 3 years full time experience drilling wells.

****

Applicant's Name: ____

Company Name: ____

Company address: ____
____
____

Company Phone No.: __________________ **Company Fax No.:** ___________________

Company E-Mail Address: ____

Proof of age (to be attached, describe nature of proof, e.g. notarized copy of birth certificate, BC driver's licence, etc.): ____
____

Proof of Qualifications (to be attached to this application - indicate category of proof provided as either (i), (ii) or (iii) as corresponding to the categories in box above): _______
Original copies of documents will be returned to the applicant.

... continued on reverse/

Note #1: As documented evidence of 5 years of full time experience drilling wells in BC or another jurisdiction, an applicant may submit letters of reference from company owners, clients or qualified professionals collectively attesting to the accumulated period of experience.

Note #2: Applications for registration as a qualified well driller using documented evidence of 5 years of full time experience drilling wells in BC or another jurisdiction (i.e. drillers using the grand-parenting provision in (i) above) will **no longer be accepted after midnight on October 31, 2006.**

Note #3: The evidence of experience drilling wells should include information on: the period of experience, employers, summary or the nature of the well drilling (i.e. methods of well construction/types of drilling, types of wells), and province or country if experience was obtained outside of British Columbia. The Deputy Comptroller of Ground Water reserves the right to request additional proof of experience to that submitted by the applicant.

Upon acceptance and approval of this application by the Deputy Comptroller of Ground Water, the applicant will be registered as a qualified well driller in British Columbia and will receive an identification card. There is **no charge** for this application or for inclusion in the register of qualified well drillers.

The Deputy Comptroller of Ground Water **may remove from the register** of qualified well drillers any person who:

- fails to meet all of the necessary requirements for registration,
- is no longer actively working in British Columbia as a qualified well driller, or
- is deceased.

A person listed as a qualified well driller in the register **must advise** the Deputy Comptroller of Ground Water in writing **within 60 days of any changes** to the information on the Register or if they are no longer actively working in British Columbia as a qualified well driller.

The information required by this form and the documents you provide with it will be used to consider your application for registration and for other purposes related to the administration of the *Water Act* and its regulations. This information will be available for examination by any member of the public. If you have any questions about the collection or use of this information, contact the Deputy Comptroller of Ground Water.

Signed: ______________________________________ Date: ____________________________

****

Completed Applications for Registration as a qualified well driller, together with all supporting evidence or documentation, **should be forwarded by mail** to:

Deputy Comptroller of Ground Water
Water Protection Section
Ministry of Water, Land & Air Protection
PO Box 9341
Victoria BC V8W 9M1

Or, **may be dropped off in person**, at:

Deputy Comptroller of Ground Water
Water Protection Section
Ministry of Water, Land & Air Protection
3rd Floor, 2975 Jutland Road
Victoria BC V8T 5J9

****

Internal use only:

Date received: ___________ Approved/Not Approved: ______________ (If not approved, attach reasons.)

Signed: __________________________________ Date: ________________________________

Title: ____________________________________

REGISTER

of **Qualified Well Pump Installers** in the Province of British Columbia

****

Pursuant to Section 2 of the ***Ground Water Protection Regulation***, the Comptroller must establish and maintain a register of qualified well pump installers who are authorized to operate in British Columbia. The list of qualified well pump installers whose names are in the Register, must be made readily available to the public during normal business hours, or be available in electronic form on the internet. A person wishing to be recognized as a qualified well pump installer in British Columbia and wanting to be listed in the Register may apply to the Comptroller pursuant to Section 4 of the ***Ground Water Protection Regulation.***

****

Well Pump Installer ID #	Name	Company Name	Company Address	Company Phone #	Company Fax #	Company E-Mail Address	Class of Well Pump Installer*	Date of registration

* The Register may list qualified well pump installers as belonging to a particular class of qualified well pump installer.

The Comptroller **may remove from the Register** of qualified well pump installers any person who:

- fails to meet all of the necessary requirements for registration,
- is no longer actively working in British Columbia as a qualified well pump installer, or
- is deceased.

A person listed as a qualified well pump installer in this Register **must advise** the Comptroller in writing **within 60 days of any changes** to the information included in the Register or if they are no longer actively working in British Columbia as a qualified well pump installer.

By listing persons as qualified well pump installers in this Register, the Province of British Columbia in no way guarantees, or may be held liable, for any work performed by the person.

The order in which persons appear in this Register is by date of registration and in no way reflects any order of preference, special favour or any other bias on behalf of the Province of British Columbia.

The person whose name appears in this Register should, in the course of their duties as a qualified well pump installer in British Columbia, **carry with them the well pump installer identification card** issued to them by the Comptroller and **must present it upon request** to the Comptroller, the Regional Water Manager, an engineer or officer under the *Water Act,* or a Drinking Water Officer under the *Drinking Water Protection Act,* as proof of their qualifications as a well pump installer pursuant to Section 71 of the *Water Act*.

APPLICATION FOR REGISTRATION

As a **Qualified Well Pump Installer**
in the Province of British Columbia

****

Pursuant to Section 4 of the ***Ground Water Protection Regulation*** a person may apply to the Deputy Comptroller of Ground Water for registration as a **qualified well pump installer** in the Province of British Columbia. The applicant for registration **must provide proof that the applicant is at least 19** years of age and **one of the following** with the application:

- **(i)** documented evidence (e.g. letter(s) and reference) from employer(s) of having a minimum of 5 years full time experience installing well pumps in British Columbia or in another jurisdiction;
- **(ii)** the original, or a notarized copy, of a Certificate of Qualification as a Well Pump Installer issued by the Province of British Columbia and documented evidence of having a minimum of 3 years full time experience installing well pumps;
- **(iii)** the original, or a notarized copy, of a certificate as a Ground Water Pump Technician of a particular class issued by the Canadian Ground Water Association and documented evidence of having a minimum of 3 years full time experience installing well pumps.

****

Applicant's Name: ____

Company Name: ____

Company address: ____

____

____

Company Phone No.: __________________ **Company Fax No.:** ___________________

Company E-Mail Address: ____

Proof of age (to be attached, describe nature of proof, e.g. notarized copy of birth certificate, BC driver's licence, etc.): ____

____

Proof of Qualifications (to be attached to this application - indicate category of proof provided as either (i), (ii) or (iii) as corresponding to the categories in box above): ________
Original copies of documents will be returned to the applicant.

... continued on reverse/

-

Note #1: As documented evidence of 5 years of full time experience installing well pumps in BC or another jurisdiction, an applicant may submit letters of reference from company owners, clients or qualified professionals collectively attesting to the accumulated period of experience.

Note #2: Applications for registration as a qualified well pump installer using documented evidence of 5 years of full time experience as a well pump installer in BC or another jurisdiction (i.e. pump installers using the grand-parenting provision in (i) above) will **no longer be accepted after midnight on October 31, 2006.**

Note #3: The evidence of experience installing pumps should include information on: the period of experience, employers, summary of size(s) and type(s) of well pumps installed, and province or country if experience was obtained outside of British Columbia. The Deputy Comptroller of Ground Water reserves the right to request additional proof of experience to that submitted by the applicant.

Upon acceptance and approval of this application by the Deputy Comptroller of Ground Water, the applicant will be registered as a qualified well pump installer in British Columbia and will receive an identification card. There is **no charge** for this application or for inclusion in the register of qualified well pump installers.

The Deputy Comptroller of Ground Water **may remove from the register** of qualified well pump installers any person who:

- fails to meet all of the necessary requirements for registration,
- is no longer actively working in British Columbia as a qualified well pump installer, or
- is deceased.

A person listed as a qualified well pump installer in the register **must advise** the Deputy Comptroller of Ground Water in writing **within 60 days of any changes** to the information on the Register or if they are no longer actively working in British Columbia as a qualified well pump installer.

The information required by this form and the documents you provide with it will be used to consider your application for registration and for other purposes related to the administration of the *Water Act* and its regulations. This information will be available for examination by any member of the public. If you have any questions about the collection or use of this information, contact the Deputy Comptroller of Ground Water.

Signed: ______________________________ Date: ______________________

****

Completed Applications for Registration as a qualified well pump installer, together with all supporting evidence or documentation, **should be forwarded by mail** to:

Deputy Comptroller of Ground Water
Water Protection Section
Ministry of Water, Land & Air Protection
PO Box 9341
Victoria BC V8W 9M1

Or, **may be dropped off in person**, at:

Deputy Comptroller of Ground Water
Water Protection Section
Ministry of Water, Land & Air Protection
3rd Floor, 2975 Jutland Road
Victoria BC V8T 5J9

****

Internal use only:

Date received: __________ Approved/Not Approved: ____________ (If not approved, attach reasons.)

Signed: ____________________________ Date: __________________________

Title: _____________________________

The Ground Water Reference Library

NEW Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Ground Water
PDF: 1.39 MB / 61 pages

A Canadian Ground Water Strategy

Abbotsford-Sumas Aquifer International Task Force

Abbotsford Environmental Pledge: Take the Pledge

An Aquifer Classification System for Ground Water Management in British Columbia

British Columbia Runoff

Code of Practice for Construction, Testing, Maintenance and Closure of Wells, Province of British Columbia
To be used along with Guidelines for Minimum Standards in Water Well Construction, June 1982.

Conversion Units

CGDS: The Computerized Ground Water Data System on the Vax

> GDS - How to enter information.
> CGDS - Simplified searches with examples.
> This system has been replaced as of October 16, 1995, with a new Vax database application referred to as WELL.

Evaluating Long-Term Well Capacity for a Certificate of Public Convenience and Necessity.

Framework for a Hydrogeologic Study in support of an Application for a Project Approval Certificate under the Environmental Assessment Act and Regulations

Framework for a Hydrogeologic Study Older document.

Fraser Valley Ground Water Monitoring Program Work Term Methodology A co-op student's work term paper with some excellent appendices on using CGDS, SEAM and sample collection. Dalia Hull January 1994.

Glossary of Ground Water Terms

Ground Water Conditions of the Columbia Valley Aquifer, Cultus Lake, British Columbia
PDF: 5 MB / 98 pages

Ground Water Consultants in BC

Ground Water Issues in British Columbia

Ground Water Issues and Research in Canada

BC Laboratory Manual and Field Sampling Manual

Ground Water Mapping and Assessment in British Columbia

These publications are also available for purchase at Queen's Printer Publications (search using ground water as a key word).
Volume 1 Review and Recommendations and
Volume 2 Criteria and Guidelines

Maps

- British Columbia British Columbia Geographic System of Mapping (BCGS).
- British Columbia Index to Numbering of Map Sheets, National Topographic Series 1975.
- British Columbia Major Regions For Indexing Purposes 1975.
- NTS Map Reference and BCGS Map Reference
- BCGS and NTS Map Translation Reference
- A Small Map of BC
- A Big Map of BC
- Vancouver Island Land Districts Guide
- Water well location mapping A catalog of available hard copy maps showing water well locations.
- Map of all water well locations in BC
- Map of all water well locations in the Lower Mainland of BC
- Map of all water well locations in the Okanagan
- GeoMap Vancouver Hydrogeological and geological mapping from the Geological Survey of Canada. Covers the Lower Mainland.

Ground Water NTS Filing System for NTS Mapsheet areas

NTS.082, NTS.092, NTS.093, NTS.094

NTS.102, NTS.103, NTS.104
NTS Consultants Reports

Practical Information on Ground Water Development

Regional District of Comox-Strathcona Aquifer Classification Project Report
PDF: 744 KB / 54 pages

The Ground Water Resources of British Columbia

Saltspring Island Ground Water Conditions, 1995

State of the Environment Report, 1992. Ground Water Component.

British Columbia Water Quality Guidelines (Criteria): 1998 Edition

British Columbia Drinking Water Quality Standards1982

Guidelines for Interpreting Water Quality Data, 1997

Guidelines for Designing and Implementing A Water Quality Monitoring Program in British Columbia, 1997

Last Updated: July 2003

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The Ground Water Well Database

Search the Well Database.

Well Query Help Notes. It always pays to read the directions.

New Well Notification for the Water Well Owner.

Search the Well Database using a clickable map interface to help you find the BCGS area of the wells you may be interested in. This is still in the early stages of development and is not the recommended search to use. It is useful if you are not familar with the British Columbia Geographic System of Mapping (BCGS).

NTS Map Reference and BCGS Map Reference.

Water Well Statistics. A few details about the history of the **WELL** database and water well drilling in British Columbia.

Register a Water Well in the **WELL** database. An experimental online data entry form.

Water Well Data Elements. A numbered listing of possible fields of interest for ground water databases. A discussion of ground water data management fields and forms.

Service Requests: The Ground Water Section provides search services for confirming information on existing records and making hard copies of available maps, records and reports. Schedule of Charges.

The Well Drilling Data Capture System

(Ground Water Data Management Version 1.0b.)
The Well Drilling Data Capture System has been designed to provide water well drillers with an easy to use customizable database that is compatible with the database systems used. This system was developed with the cooperation and assistance of the British Columbia Ground Water Association. With this system water well drillers will be able to organize and maintain their own water well data, print out water well records for customers and export data selected by the driller to the WELL database. Minimum system requirements are a personal computer capable of running the Windows 95/98/NT operating system.

Ground Water Consultants in British Columbia

Consulting Ground Water Specialist Firms Practising in BC

LISTED ALPHABETICALLY BY COMPANY NAME:

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

LISTED ALPHABETICALLY BY CONTACT (last name):

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

-- A --

AMEC Earth and Environmental Ltd.
Scott Green, P. Eng.
913 Laval Crescent
Kamloops, BC V2C 5P4
Phone: (250) 374-1347
Fax: (250) 374-2944

-- B --

Brown, Erdman and Associates Ltd.
William Brown, P. Eng.
382 Mathers Avenue
West Vancouver, BC V7S 1H3
Phone: (604) 926-0184
Fax: (604) 980-3601

-- C --

Can Test Ltd.
Anglina Elliot
200 - 1523 West 3rd Avenue
Vancouver BC V6J 1J8
Phone: (604) 734-7276
Fax: (604) 731-2386

Conestoga-Rovers & Associates Ltd.
Daniel St-Gelais, M.Sc., P.Eng.
Airport Executive Park
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Richmond, BC V6X 2W9
Phone: (604) 214-0510

Fax: (604) 214-0525
E-mail: Conestoga-Rovers & Associates Ltd.

-- D --

Dayton and Knight Ltd.
D. R. Harrington
626 Clyde Ave. Box 91247
West Vancouver, BC V7V 3N9
Phone: (604) 922-3255

-- E --

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Whitehorse Yukon Y1A 2V3
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Professional Hydrogeologist
Calcite Business Center, Unit 6, 151 Industrial Road
Whitehorse Yukon Y1A 2V3
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Fax: (867) 668-4349
Email: mpye@eba.ca

Emerson Ground Water Consultants Inc.

Daniel Emerson, P. Geo.
10504 Main Street
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Ground Water Issues in British Columbia

Statistics compiled in 1981, showed that 22 percent (600,000 persons) of the Province's population depended upon ground water for water supply. Although the volume of ground water extracted amounts to only ten percent of total water consumption in British Columbia, because of the large quantities of water used in the province, this represents twenty-five percent of all the ground water extracted in Canada. The largest use of ground water in the province is by industry (55%), followed by agricultural (20%), municipal (18%) and rural domestic (7%). Certain areas are entirely dependent upon ground water for water supplies.

Numerous ground water resource conflicts currently exist in various parts of the province such as:

*well interference where large capacity wells lower water levels and yields of neighbouring wells, (e.g. Surrey, Mill Bay, Saanich);

*artesian wells which are allowed to flow freely thereby wasting water and lowering water levels and yields in neighbouring wells, (e.g. Surrey, Okanagan, Gulf Islands, Saanich);

*ground water-surface water conflicts, particularly where surface water is fully licensed and ground water extraction depletes surface flows and availability, (e.g. Cherry Creek /Kamloops, Chimney Creek / Williams Lake, Kalamalka Lake);

*excessive ground water withdrawals in coastal areas resulting in salt water intrusion and quality degradation, (e.g. Gulf Islands, Saanich);

*poor well construction practices which result in degradation of ground water quality and contamination, (e.g. Gulf Islands, Saanich);

*health risks, public safety and environmental hazards associated with uncapped and abandoned wells, (e.g. Lower Mainland and Okanagan Valley).

In some areas of the Province, shallow ground water is also susceptible to non-point or diffuse sources of contamination from various activities, such as the unregulated use of chemical fertilizers and pesticides combined with excessive irrigation practices, and the application, disposal and storage of animal wastes on land. Elevated levels of nitratenitrogen in excess of the Canadian Drinking Water Quality Guideline of 10 mg/L, for example, have been found in a significant number of domestic wells in the LangleyAbbotsford, Osoyoos and Grand Forks areas of the Province. Point sources of contamination such as abandoned landfills, chemical spills and former industrial sites are also causing water quality degradation in some areas.

In 1982, the Ministry of Environment (Water Management Branch), in cooperation with the well drilling industry, prepared Guidelines for Minimum Standards in Water Well Construction, Province of British Columbia. Compliance with these standards ensures that water wells are drilled and finished in a manner that protects the health, safety and welfare of the public and the integrity of the resource.

These have been adopted in varying degrees by water well drillers, consultants in the industry and local governments but are not mandatory on a province-wide basis.

In 1986, the Provincial Apprenticeship Board approved the designated trade of Water Well Driller and the regulations for trade qualification and certification by the Ministry of Labour (now the Ministry of Advanced Education and Job Training).

Water well drilling is a recognized trade in the province, and individuals meeting the specified qualifications can hold a Certificate of Qualification as a Water Well Driller. Certification, however, is not mandatory for an individual to work at the trade. An approved training program for Water Well Drillers was finalized in 1986 under the auspices of the Ministry of Advanced Education and Job Training. The Program was developed by a Trade Advisory Committee comprised of representatives of the Ministry of Environment (Water Management Branch), the B.C. Water Well Drilling Association and the Ministry of Labour.

Well construction is addressed in Guidelines for Minimum Standards in Water Well Construction developed by the Water Management Program and the British Columbia Water Well Drilling Association. Well drillers may also apply for certification as a Water Well Driller. Both of these measures are entirely voluntary.

Many old water wells as well as other forms of excavation such as test wells and foundation test holes, may not be properly capped or filled in, thereby posing a potential safety hazard.

In some areas, well interference problems and impacts on surface water resources are serious. Further well drilling and surface water allocation in these areas would threaten the integrity of the entire hydrologic regime, severely impacting individual water users and ecologic systems dependent upon the water resource. Ground water maintains baseflows in rivers and streams during periods of drought and is a critical component to maintaining fisheries habitat and spawning areas.

Many ground water quality problems emanate from inappropriate land-use practices directly over susceptible aquifers: eg., over-application and runoff of agricultural fertilizers and chemicals which may result in high nitrates and pesticides in ground water; land disposal of sewage effluent; chemical spills or leakage from storage tanks and transportation facilities; poorly sited landfills; and incorrect waste disposal practices at former industrial sites. Infiltration of rainfall, snowmelt and streamflow in ground water recharge areas may carry contaminants to ground water especially in sensitive areas where water tables are shallow and surface soils consist of permeable sand and gravel deposits. Areas of ground water discharge and immediate environs surrounding these sites (e.g., natural springs and wetlands), need to be protected from sources of contamination.

Regulation of such land-based activities currently falls under the mandates of the Waste Management Act, the Pesticide Control Act and the Health Act.

Property owners may carry out activities at or near well heads that can threaten the ground water resource. Activities near wells such as storing or mixing chemicals, filling pesticide application containers, applying chemicals through irrigation systems or dumping waste materials can result in ground water contamination. Unused wells in some instances have been used to dispose of various wastes.

Ambient ground water quality is being monitored by the Water Management Program in a number of observation wells in the settled areas of the province, and in specific aquifers where contamination from non-point sources is evident. Point sources of contamination are monitored under the Environmental Protection Program. Water supply systems dependent upon ground water are tested by the purveyors and the Ministry of Health. The Water Quality Check Program administered by the Ministry of Environment, Lands and Parks provides for laboratory analysis of individual water supply sources for homeowners at a subsidized cost.

Some aquifers show evidence of ground water contamination to a point of being impaired or unfit for use, particularly for drinking water purposes. Sources of contamination may be due to natural levels of constituents or from human-induced sources. From an allocation perspective, ground water use without provisions for adequate treatment should not be allowed in areas of known risk to human health. Areas of known or suspected contamination need to be identified and designated as such.

Ground water quantity information in the form of well records are currently submitted by well drillers to the Water Management Program on a voluntary basis. A similar situation exists for ground water assessment reports prepared by consulting firms in the ground water industry. Well record information is compiled, processed and stored in paper files, on microfiche and on computer systems.

A network of 150 observation wells throughout the province provides current and historic information (20 to 30 years in some cases), on water level fluctuations in the major areas of ground water use.

Ground water quality information in the form of laboratory analyses obtained from the Water Quality Check Program and other sampling activities is available for several thousand wells, but because of incomplete documentation of sampling sites in many cases and limited resources for processing this information, much of the data has not been linked to other databases on wells and specific geographical locations.

On June 21, 1995, The Water Protection Act received Royal Assent. Section 3 (2) states: "The property in and the right to the use, percolation and any flow of ground water, wherever ground water is found in British Columbia, are for all purposes vested in the Crown in right of British Columbia and are conclusively deemed to have always been vested in the Crown in right of British Columbia."

The *Drinking Water Protection Act,* 2001.

Our vision is a sustained and healthy ground water resource.

Ground Water

British Columbia *Environmental Assessment Act*:
Reviewable Ground Water Projects

What is the *Environmental Assessment Act*?

The British Columbia *Environmental Assessment Act* requires that certain types of project proposals undergo an environmental assessment and obtain an environmental assessment certificate in order to proceed. The current legislation came into effect in December 2002, replacing the previous *Environmental Assessment Act*, which had been in effect since June 1995. The provincial government is committed to more flexible, efficient, and timely reviews of proposed major projects to help revitalize the provincial economy. This is why a new, streamlined environmental assessment process was introduced in 2002.

The environmental assessment process identifies and assesses the potential effects that may result from a proposed project, and considers measures to minimize or avoid adverse effects. The scope, procedures and methods for each assessment are tailored to the circumstances of the proposed project.

When is a Ground Water Project Reviewable under the *Environmental Assessment Act?*

New Facility

" The development of a new facility is reviewable if it consists of one or more wells, operated either periodically or continuously for one year or more, designed to be operated to extract ground water at the rate of 75 litres or more per second.

Modification to an Existing Facility

" Where an existing facility is designed to extract ground water at a rate of 75 litres or more per second, modifications to the facility are reviewable if the modifications will increase the rate of extraction by 35% or by 75 litres per second or more.

" Where an existing facility is designed to extract ground water at a rate of less than 75 litres per second, modifications to the facility are reviewable if the modifications will increase the rate of extraction by 35 % and result in an extraction rate for the facility of 75 litres per second or more.

Federal Requirements

The Canadian *Environmental Assessment Act* may apply to certain ground water extraction proposals where the rate of ground water extraction is greater than 200,000 m3 /a (about 7 litres per second) or to modifications that increase production capacity by more than 35 %. Should there be a requirement for review under both provincial and federal environmental legislation, the provincial Environmental Assessment Office will arrange for a joint review to avoid duplication and to streamline the review process.

For more information about the environmental assessment review process and projects that are reviewable under the *Environmental Assessment Act*, contact the Environmental Assessment Office:

Website: www.eao.gov.ca
PO Box 9426 Stn Prov Govt
Victoria, BC V8W 9V1
Phone 250 356-7479
Fax: 250 356-7440

Water Well Location Maps

Aquifers and Water Wells in BC

This interface to ground water aquifers and water well locations is under development and now replaces other methods of delivering ground water data to the public, consultants and water well drillers.

The Ministry no longer provides hard copies of maps.

A catalog of water well location maps.

For BCGS mapsheets Generally newer better quality mapping.
For Land Districts Generally older mapping of varying quality.

Other Maps and Guides

- British Columbia. British Columbia Geographic System of Mapping (BCGS).
- British Columbia. Index to Numbering of Map Sheets, National Topographic Series 1975.
- British Columbia. Major Regions For Indexing Purposes 1975.
- NTS Map Reference and BCGS Map Reference.
- BCGS and NTS Map Translation Reference.
- A Small Map of BC.
- A Big Map of BC.
- Vancouver Island Land Districts Guide.
- Map of all water well locations in BC.
- Map of all water well locations in the Lower Mainland of BC.
- Map of all water well locations in the Okanagan.
- **GeoMap Vancouver.** Hydrogeological and geological mapping from the Geological Survey of Canada. Covers the Lower Mainland.

A Preliminary Survey of Methyl Tertiary-Butyl Ether (MTBE) in Ground Water at Selected Well Sites in British Columbia, Canada

W. S. Hodge, P. Geo.
Ground Water Hydrologist
Ground Water Section
Water Protection Branch

August, 2001

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A Preliminary Survey of Methyl Tertiary – Butyl Ether (MTBE) in Ground Water at Selected Well Sites in British Columbia, Canada

by W.S. Hodge, Ground Water Hydrologist, Water Protection Branch

Executive Summary

Methyl Tertiary – Butyl Ether (MTBE) was mandated by the US Environmental Protection Agency as a gasoline additive in 1979 to reduce air pollution and is part of a reformulated gasoline to increase oxygen in the gasoline causing it to burn more cleanly in automobiles. Gasoline containing MTBE is also distributed in Canada, however as of late 2000, MTBE is no longer sold in British Columbia. MTBE is highly soluble and can move rapidly through soils and aquifers. Concern over MTBE contamination of ground water in British Columbia was raised during the November 2000 Legislative Report of Proceedings from the Public Accounts Committee. As part of the Provincial Government's response over this concern the Ground Water Section of the Water Protection Branch conducted a ground water sampling program between June and November 2000. A total of 76 water samples were collected from 58 domestic wells, observation wells and piezometers located in the Lower Mainland, Vancouver Island, and the Interior of BC. Most wells sampled were completed in sixteen shallow, unconfined, highly vulnerable, sand and gravel drinking water aquifers that are regularly monitored by Ground Water Section as part of the Province's Observation Well Network and Ambient Ground Water Quality Monitoring Network. The sampling did not target specific sites contaminated by hydrocarbons. Of the 76 samples analyzed by Analytical Service Laboratories Ltd. all MTBE results were <1.0 part per billion (ppb) except one well, domestic well "U" located in the Abbotsford-Sumas Aquifer. This well had a slight detect of 2.0 ppb MTBE, was re-sampled in December 2000 by Regional Water Management staff and MTBE was confirmed at 3.0 ppb, well below the British Columbia drinking water guideline of 20 ppb based on taste and odour thresholds. Quality assurance / quality control (QA/QC) procedures including taking duplicate samples were followed each time the portable pump was used. The pump and discharge hose were decontaminated by pumping distilled water through the system and submitting this washed sample to ASL for analysis. All QA/QC results were negative. A field survey was conducted in February 2001 to identify potential sources of contamination and to sample wells located approximately 1 km radius of well "U" where MTBE was detected. The majority of surrounding residences were, however, connected to the City of Abbotsford water supply and only 2 residences were using well water for domestic use. These wells, including domestic well "U", were re-sampled in February 2001 and MTBE results were <1.0 ppb MTBE for all three wells suggesting that the very low levels of 2.0 and 3.0 ppb MTBE may have naturally flushed through the aquifer. Possible sources of MTBE included nearby gasoline

storage tanks on private properties. Well owners should protect their water source from MTBE contamination by inspecting the immediate area around their well and pump house and relocating or safeguarding any potential contaminant sources such as gasoline storage tanks a safe distance from their water source.

A Preliminary Survey of Methyl Tertiary-Butyl Ether (MTBE) in Ground Water at Select Well Sites in British Columbia, Canada

1. **Occurrence and Physical Characteristics of MTBE**

   Methyl tertiary-butyl ether (MTBE) is a colourless, volatile organic compound (VOC) produced almost exclusively for use in gasoline. It is made of methanol and a by-product of the oil refining process. Oxygenates (MTBE, Ethanol) were mandated by the USEPA in certain areas as a gasoline additive in 1979 to reduce air pollution and is part of a reformulated gasoline to increase the amount of oxygen in gasoline causing it to burn more cleanly in automobiles. Such reformulated gasolines typically may contain up to 15 percent of MTBE to reduce vehicle carbon monoxide emissions. MTBE has been reported to occur in Western Canada gasoline at an average level of 0.44 percent by volume for all brands, (Tushingham, Hodge, and Roberge, 2000).

   MTBE is lighter than water and has a high solubility in water. The specific gravity of MTBE is 0.740 grams/cm^3 (Aldrich, 1994) whereas water has a specific gravity of 1.00 gram/cm^3. Because MTBE has a high solubility in water, it can readily dissolve in ground water and be transported as a dissolved species by ground water flow. Table 1 summarises some basic physical properties of MTBE and another component of gasoline (benzene) which is included for comparison. MTBE is resistant to microbial decomposition and is difficult to remove in water treatment. It's turpentine taste and smell renders water undrinkable at even 30 parts per billion (ppb).

   MTBE concern was raised in the November 2000 Legislative Report of Proceedings from the Select Standing Committee on Public Accounts. Concern over MTBE contamination to ground water was discussed on several occasions including the potential hazards presented to rivers and aquifers from gasoline pipelines crossing the Province and transport of MTBE in concentrated form by truck and rail. The importance and results of the province wide sampling program being carried out were also discussed during these proceedings.

   Common sources of MTBE are leaking underground fuel storage tanks, spills at gasoline storage sites and storm water runoff from roads and parking lots.

Table 1 – Physical Properties	MTBE	Benzene
Molecular Weight	88.15	78.11

Specific Gravity (g/cm^3)	0.740	0.874
Solubility (mg/L) at 20^0C	4700	1780

2. **Objectives of MTBE Sampling Program**

In order to survey how widespread MTBE might be present in the ground water (and aquifers) in British Columbia, sampling was carried out in conjunction with the 2000 / 2001 Observation Well Network and Ambient Water Quality Network sampling programs.

Briefly, the Observation Well Network is comprised of about 160 wells located in major ground water areas of British Columbia. Each year about 25 of these wells are sampled for inorganic chemical analysis. For further information on the Observation Well Network see the Fact Sheet (Appendix A). The Ambient Water Quality Network was initiated in the late 1980's and comprises about 45 domestic wells and 40 piezometers that are sampled once a year for inorganic chemical analysis to monitor non-point source contamination of nitrate in three regions: Lower Mainland, Osoyoos, and Grand Forks.

Whenever an observation well or domestic well was sampled for regular sampling, MTBE sampling was included. This sampling program was conducted to provide a preliminary survey to check for the presence of MTBE in ground water.

Site-specific sampling of ground water beneath known hydrocarbon contaminated sites was not carried out during this preliminary sampling program. The Ground Water Section sampling program was one component of a number of components to the provincial government response to concerns over MTBE contamination. Preliminary sampling for MTBE was also undertaken by the Ministry of Health Services and local health regions for a number of community water supply systems. Other work has been preparation of a Fact Sheet on MTBE completed in the spring of 2000 (Appendix B) to raise public awareness and the development of Water Quality Guidelines for MTBE. Water quality guidelines for MTBE are available at: http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/mtbe.html The MTBE guideline for drinking water in British Columbia is set at 20 ppb based on taste and odour thresholds.

This report presents the Ground Water Section's MTBE sampling procedures and sampling results and provides recommendations to well owners for protecting and safeguarding their water supplies by identifying and removing potential contaminants (i.e. gasoline storage tanks) a safe distance from the well.

3. **MTBE Sampling Program and Site Selections**

The sampling program included sampling of all established domestic wells within the Ambient Water Quality Network Program in the Lower Mainland, Osoyoos, and Grand Forks, specific observation wells and select irrigation wells in Keremeos. The majority of the wells sampled are shallow, dug and drilled wells and are located in highly vulnerable, unconfined sand and gravel aquifers except observation well No. 65 (located in Saanich, just north of Victoria) which is completed in a bedrock aquifer (Table 2).

During the summer and fall of 2000, the Ground Water Section, Ministry of Environment, Lands and Parks collected a total of 76 samples from 58 wells located in sixteen aquifers in the Lower Mainland, Vancouver Island and the Interior of BC (Figure 1). For privacy reasons, domestic well owners' names have been abbreviated as shown in Table 2 and throughout the text. All wells sampled are shown in Table 2. A photograph of a typical domestic well sampling site is shown in Appendix C.

4. **MTBE Sampling Procedures**

Domestic wells were sampled by turning the inside or outside water tap closest to the well on and filling 2-40 ml purge and trap glass vials. The sample vials contained a small amount of sulphuric acid as a preservative. The sampling locations have been previously established and tagged during the regular sampling program.

Sampling of observation wells and piezometers was carried out by installing a portable submersible pump, pumping the well or piezometer for a specified period (2 to 5 well volumes if possible) through a hose and then collecting and shipping the samples in the same manner as the domestic well sampling. Specific conductance and water temperature were taken at regular intervals during pumping to determine the optimal time for sample collection.

As a quality control measure and to minimize cross contamination by the pumping equipment between wells, decontamination procedures were carried out. Pump decontamination procedures have also been included in Appendix D.

5. **Land Use Survey**

Prior to sampling a well, a visual inspection around the vicinity of the well was carried out to locate and identify any potential MTBE sources. MTBE sources such as gasoline stations, gasoline storage tanks and utility storage sheds were noted. This inspection was preliminary and carried out with the intent of obtaining more detail if a particular well showed the presence of MTBE after initial sampling. If MTBE was detected in a well then a detailed land survey in the vicinity of the wellhead would be carried out when the well was re-sampled to verify the presence of MTBE. The general land use around each well sampled is indicated in Table 2.

6. **Analytical Service Laboratories Ltd.**

All samples were forwarded by courier to Analytical Service Laboratories Ltd. (ASL) in Vancouver for MTBE analysis. The purge and trap 40 ml vial samples were analysed by a Gas Chromatograph Mass Spectrometer with purge and trap sample introduction. ASL was able to analyse and detect MTBE to <1.0 ppb. The turn around time between sample submission and reporting of results was about 10 working days.

7. **MTBE Sampling Results and Discussion**

All MTBE results as shown in Table 2 were <1.0 ppb except for domestic well "U" (2 ppb) located in the Abbotsford area (east of Vancouver).

Well "U" was re-sampled in December 2000 to check the 2.0 ppb result of November 2000. The follow-up sample contained 3.0 ppb MTBE. In February 2001, a field survey was carried out and residences within approximately 1 km radius of well "U" were contacted. Only two other residences were found to be using private well water for domestic use within the surveyed area. The remaining residences are connected to the City of Abbotsford water supply. The three wells were sampled and samples were submitted to ASL for MTBE analysis. The three sample results were <1.0 ppb MTBE including domestic well "U". The fact that MTBE was not detected in "well U" in the February 2001 sample suggests that the low levels of 2.0 and 3.0 ppb MTBE may have naturally flushed through the aquifer. During the field survey of well "U" some potential sources of MTBE were noted. Gasoline and diesel fuel storage tanks on a wooden pedestal were noted located approximately 60m (200 ft) east and slightly down slope of well "U". It was further noted that the pedestal was located on a coarse gravel base and not a concrete or spill containment pad. A gasoline tank on wooden pedestal also on a gravel base was located directly behind the residence. A buried gasoline tank (s) with two hand pumps at surface was noted beside the driveway of a neighbouring property. The hand pumps were padlocked.

This was a preliminary sampling program. It was carried out to determine if MTBE contamination was prevalent in British Columbia and if it was present in shallow unconfined vulnerable aquifers in British Columbia that are regularly monitored. Results should not be interpreted to indicate all similar aquifers are necessarily safe from MTBE contamination nor that MTBE is not present in the aquifer elsewhere. Any future sampling should also target wells located near industrial or commercial areas where the possibility of detecting MTBE is more likely to occur.

Quality assurance and quality control measures (QA/QC) were taken for those observation wells that were pumped using the portable Redi-Flo pump. Following sample collection, step-by step decontamination procedures as shown in Appendix D were taken. QA/QC sample results indicated that use of the portable Redi-Flo pump did not have any effect on the results.

8. **Conclusions and Recommendations**

- The MTBE Preliminary Sampling Program included sampling established domestic wells in the Ambient Water Quality Program Network and specific Observation Wells. The sampling Program did not specifically target any known hydrocarbon contaminated sites. The purpose of the sampling program was to survey a number of aquifers across the province for the presence of MTBE.
- Fifty-eight wells located in the Lower Mainland, Vancouver Island, and the Interior of BC were sampled for MTBE during the summer and fall of 2000. A total of 76 samples were submitted for analysis.
- The sampling program covered a total of sixteen drinking water aquifers. Most wells sampled were shallow, dug and drilled wells and located in unconfined, highly vulnerable aquifers. All wells sampled were from surficial aquifers except observation well 65 (Saanich) which is located in a fractured bedrock aquifer.
- Whenever an observation well was pumped, the pump and hose were washed (decontaminated) using distilled water to identify if cross-contamination of the pumping equipment was an issue. The washed samples were also submitted to ASL Ltd. for analysis as a quality assurance / quality control measure. All QA/QC sample results were <1.0 ppb.
- Of the 76 samples submitted to ASL Ltd. all results were < 1.0 ppb except domestic well

"U" located in Abbotsford which had an initial detection of 2.0 ppb MTBE. This well was re-sampled in December 2000 by Regional Water Management Staff and MTBE was confirmed at 3.0 ppb. In February 2001, a field survey was carried out and residences within approximately 1 km radius of this well were contacted. Only two other residences were found to be using well water for domestic use within the surveyed area. The remaining residences are connected to the Abbotsford City water supply. The three wells were sampled and submitted to ASL for analysis. The three sample results were <1.0 ppb including domestic well "U". Based on these results it would appear that the November and December 2000 MTBE results of 2.0 ppb and 3.0 ppb respectively may have naturally flushed through the aquifer. It should be further noted that MTBE levels of 2.0 or 3.0 ppb are just above the detection limit and below the MTBE guideline for drinking water in British Columbia set at 20 ppb based on taste and odour thresholds.

- During the February 2001 field survey of well "U" some potential sources of MTBE were detected in close proximity to the well including a nearby gasoline and diesel tank located on a wooden pedestal over coarse gravel. This survey was carried out at this time with the intent of identifying <u>potential</u> sources of ground water contamination, and not to assess these sources more fully to determine if they were indeed contaminating the underlying soils and aquifer.
- Based on the results obtained from this survey and preliminary results of independent sampling by local health authorities of a limited number of high risk community wells (Egan, pers comm, 2001), MTBE in ground water does not appear to be a problem at this time.
- The Ministry of Water, Land and Air Protection (MWLAP) should continue to sample a limited number of high risk observation wells completed in unconfined, highly vulnerable aquifers for MTBE in 2001/2002. Results should not be interpreted, however, to indicate that all similar aquifers are safe from MTBE contamination nor that MTBE is not present locally in the sampled aquifer elsewhere. Any future sampling should include wells located near industrial or commercial areas where the possibility of detecting MTBE may be increased.
- Private well owners and purveyors should protect and safeguard their water source by inspecting the immediate area around their well and / or pump house and identify and relocate potential contaminants such as petroleum products and gasoline storage tanks <u>at least</u> 30m (100 ft) distance from their water source and providing safeguards such as spill containment facilities to contain any leaks. In some cases this distance may need to be increased depending on specific site conditions.

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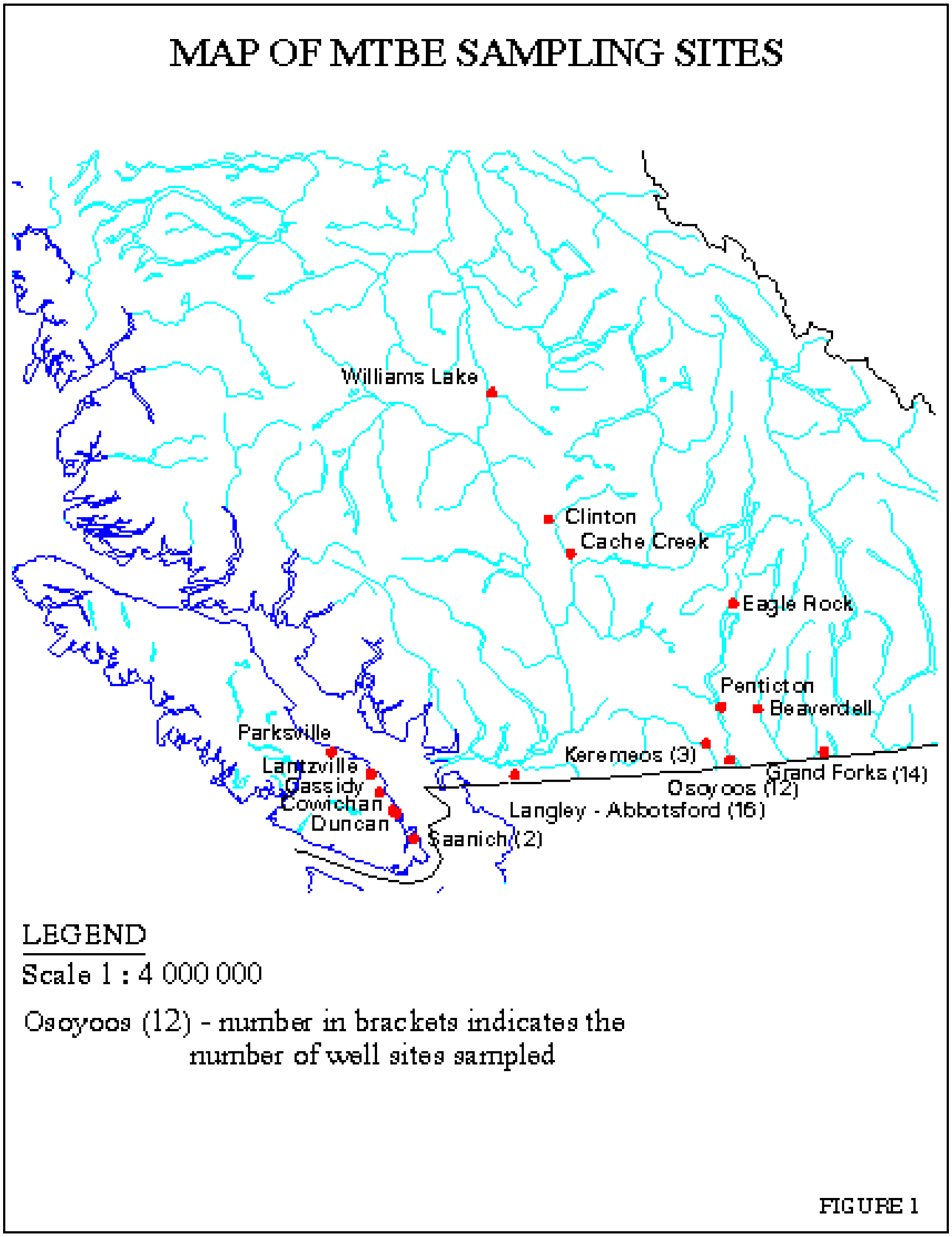

[APPENDIX A]

- Ground Water Observation Well Network in British Columbia

[APPENDIX B]

- MTBE in Ground Water

[APPENDIX C]

- Photograph of Typical Domestic Well Sampling Site

APPENDIX D

- Step by Step Decontamination Procedures for MTBE Sampling from Observation Wells and Piezometers

APPENDIX D

Step by Step Decontamination Procedures for MTBE Sampling from Observation Wells and Piezometers:

- Fill a clean 21 litre (5 gallon) plastic bucket with distilled water and place the pump inside the bucket washing the outside of the pump and pump sleeve.
- With the pump fully submersed in the 21 litre (5 Imperial gallon) bucket, pump and flush the pump and hose for approximately 5 minutes. Reduce the flow to about 0.02 to 0.04 L/s (1/4 to1/2 Igpm) and top the bucket up with distilled water while pumping to ensure that the bucket is always full.
- After about 5 minutes reduce the flow further and collect another 2-40 ml vials ensuring that the vials do not overflow and there is no head space in the vial. These vials are submitted to ASL and analyzed for MTBE.

Ground Water Protection Regulation - Phase 1

Protecting the Ground Water Resources of British Columbia

Backgrounder

Quick Jumps

Introduction

On July 7, 2004, in Chilliwack, the Honourable Bill Barisoff, Minister of Water, Land and Air Protection publicly announced that the government has enacted the Ground Water Protection Regulation (GWPR). The GWPR is designed to protect British Columbia s valuable ground water resource.

The GWPR deals with aspects of well construction that significantly enhance ground water protection i.e., installing effective surface seals around wells, securely capping and floodproofing wells, and permanently closing unused wells to protect ground water quality. The GWPR also establishes the qualifications for well drillers and well pump installers and provides for a provincial registry of those possessing the qualifications.

Registration provisions in the GWPR for qualified well drillers and qualified well pump installers will come into force on November 1, 2004, as will amendments to the *Water Act* (2001) providing for ground water protection. One year later, on November 1, 2005, the remainder of the GWPR provisions will take effect.

Prior to the GWPR, there was no regulation in British Columbia focussing specifically on ground water or standards for well construction, maintenance, well closure and qualifications for well drillers and well pump installers. Unregulated drilling activities and lack of enforceable well construction standards have contributed to ground water quantity and quality problems in some areas of the province. For example:

- bacteriological contamination of private domestic wells is a problem in local areas of the province;
- old, unused wells are often left unfilled and uncapped and become pathways for contaminants to enter directly into the underlying aquifer; unused wells may even be used for disposal of household and hazardous wastes, causing degradation to local ground water quality; and
- wells and test holes are not always constructed or tested by qualified persons with the knowledge necessary to safeguard drinking water sources and prevent situations where ground water may be adversely affected.

In 2000, the Walkerton tragedy was a wake-up call to all Canadians that a similar tragedy could happen elsewhere. At the same time, a number of reports critical of source water protection had sounded warnings, including:

- Auditor General's 1998/99: Report 5 on Protecting Drinking-Water Sources
- Provincial Health Officer (2001). A report on the health of British Columbians. Provincial Health Officer s annual report 2000. Drinking water quality in British Columbia: The public health perspective.
- Final Report: Panel Review of British Columbia s Drinking Water Protection Act, 2002.

· Top

In 2001, the government made a New Era commitment to pass real comprehensive ground water legislation to improve the quality of British Columbians drinking water, and announced its Action Plan for Safe Drinking Water in British Columbia in June 2002. On the advice of its Drinking Water Review Panel, government reaffirmed the ground water legislation by passing the *Drinking Water Protection Amendment Act* in October 2002. This led directly to the appointment of the Ground Water Advisory Board to provide advice and recommendations and the development of Phase 1 of the Ground Water Protection Regulation.

The new GWPR is the first phase of a comprehensive Ground Water Protection Regulation and includes critically needed standards for well construction and closure, floodproofing of community wells, well identification and qualifications for well drillers and well pump installers. Subsequent phases will reinforce these source protection measures and deal with such matters as well reports, well pumps, flow testing, water analyses and aquifer quality and quantity protection and use.

What is the Ground Water Protection Regulation and What Does it Cover?

The primary purpose of the Ground Water Protection Regulation is protection of the quantity and quality of the province s valuable ground water resource by:

- setting out standards to safeguard and maintain the integrity and efficient use of the ground water resource, and
- ensuring activities related to well water and ground water are undertaken in an environmentally safe manner.

The GWPR is a regulation under the *Water Act*.

The GWPR will be completed in three phases.

Phase 1 (completed and announced July 7, 2004) covers:

- qualifications for well drillers and well pump installers,
- a register for qualified well drillers and well pump installers,
- ground water protection through flood proofing, surface sealing, well caps and covers, protection of the well head, and deactivating or closing of wells (well construction standards), and
- well identification.

Phase 2 will focus on:

- additional standards for well construction, flowing wells, well pumps, flow testing and well operation,
- water analysis for new and altered wells,
- well reports, and
- the establishment of offences for which tickets may be issued.

Phase 3 will focus on:

- implementing water management plans in designated areas,
- drilling authorizations (if necessary) and
- other measures for aquifer quality and quantity protection and use.

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The GWPR Phase 1 is in two parts:

- the main body is results-based and specifies what must be achieved but not how to achieve it, and
- Appendix A (the Code of Practice for Construction, Testing, Maintenance, Alteration and Closure of Wells in British Columbia , or simply the Code) sets out the minimum rules or standards in relation to wells.

The GWPR applies to water supply wells (i.e., domestic wells and non-domestic wells, such as irrigation wells), ground water monitoring wells, recharge and injection wells, dewatering or drainage wells, remediation wells and geotechnical wells that do not involve water transfer (i.e., boreholes, test pits, closed geo-thermal and special types of holes). The GWPR does not apply to geothermal wells, oil and gas wells, or wells used for coalbed methane extraction which are already regulated under other acts, like the *Geothermal Resources Act*, *Mines Act*, and *Petroleum and Natural Gas Act*.

The GWPR does not restrict a well owner s ability to drill new wells. Wells regulated under the GWPR are not licensed and the province does not charge any fees or rentals for extraction of ground water.

Specific provisions of the GWPR Phase 1 include:

- Qualified well drillers and well pump installers must register with the province. Registration begins November 1, 2004. The GWPR recognizes the Industry Training Centre and Canadian Ground Water Association certification. The GWPR includes a grand-parenting provision (available until October 31, 2006) for individuals who can demonstrate that they have the equivalent of 5 years full time experience drilling wells or installing well pumps.
- The GWPR provides for a provincial registry of qualified well drillers and well pump installers.
- Under the GWPR, qualified professionals (Professional Engineers and Professional Geoscientists with competency in hydrogeology or geotechnical engineering) play a role in enhancing regulatory efficiency and flexibility. The GWPR authorizes qualified professionals to approve alternative specifications where it is not feasible to comply with the specifications set out in the Code. This is similar to the role of qualified professionals on the Contaminated Sites roster under the new *Environmental Management Act*, enacted in 2002.
- Well drillers are to attach identification plates (provided by the province) to new water supply wells. All existing community wells are to be tagged with well identification plates before November 1, 2006.
- New wells (with minor exceptions) are to have an effective surface seal.
- New wells (with minor exceptions) are to have a secure cap or cap and cover. Existing wells are to be capped within two years.
- Standards for floodproofing will apply to all community wells to prevent direct entry of floodwaters into the well.
- All wells not in use will need to be deactivated or permanently closed to protect ground water.

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The new GWPR is the initial step toward fulfilling Government s commitment insofar as it represents the first of three phases that, taken together, will make the legislation truly comprehensive (phases two and three are planned for 2005/06 and beyond).

The GWPR may be found here.

Why is the Ground Water Protection Regulation Needed?

In British Columbia, ground water is a valuable natural resource in need of protection. Over 750,000 residents rely on wells as a drinking water supply. British Columbia uses more ground water than any other province in Canada, except Ontario. Seventy-five percent of the ground water extracted in the province is used to support the province s economy (e.g., mineral / paper processing, agriculture, etc.). There are more than 100,000+ water supply wells in the province. Approximately 3,000 new wells are drilled and hundreds are abandoned annually. These wells have never been subject to any enforceable standards for well construction, maintenance and closure. In fact, prior to the GWPR being enacted, British Columbia was the only province in Canada without regulations to protect ground water.

Unregulated drilling activities and lack of enforceable well construction standards have contributed to a number of ground water quantity and quality problems in some areas of the province. These problems could potentially affect human health, public safety and property values. For example:

- bacterial contamination of private domestic wells is a problem in local areas of the province;
- old, unused wells are often left unfilled and uncapped and become pathways for contaminants to enter directly into the underlying aquifer; unused wells may even be used for disposal of household and hazardous wastes, causing degradation to local ground water quality; and
- wells and test holes are not always constructed or tested by qualified persons with the knowledge necessary to safeguard drinking water sources and prevent situations where ground water may be adversely affected.

Impacts of the Ground Water Protection Regulation

How will the Ground Water Protection Regulation benefit all British Columbians?

All British Columbians will benefit from the added aquifer protection of the Ground Water Protection Regulation. Some of the benefits include:

- securing a safe and healthy ground water resource and reducing risk of degradation of water quality and depletion of aquifers,
- increased public confidence in ground water resources,
- improved integrity and safety of wells and community drinking water supplies (consumer protection),
- consistent province-wide performance standards for well drillers and well pump installers (level playing field),
- improved tracking of wells and their condition,
- a system of ground water protection that is efficient and accountable,
- clearer responsibility of well owners to maintain wells in safe and sanitary conditions, and
- enhanced protection of aquatic ecosystems dependent on ground water.

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How will the Ground Water Protection Regulation affect me as a water well owner in British Columbia?

Owners of all new and existing wells should be aware of their new responsibilities under the GWPR. These responsibilities include the need for on-going maintenance of the well and the well head while the well is in use, capping or covering a well and properly closing the well at the end of its useful life.

The GWPR will add slightly to the cost to construct new water supply wells (~4% of the cost for a typical water supply well). The slight increase in cost is mainly for the installation of a surface seal, which is necessary to provide sanitary protection to the well supply. Another cost to the well owner (~6%) is for closing the well after its useful life has been exceeded (generally about 25 years) to prevent the risk of ground water contamination. The minor financial costs are considered acceptable in light of the improved water quality protection benefiting the well owner, other surrounding owners, and the resource.

How will the Ground Water Protection Regulation affect community wells (i.e., wells having more than one connection) and water suppliers?

Water suppliers using community wells, also called water supply system wells, should be aware of their new responsibilities under the GWPR.

Requirements for well identification apply to new and existing community wells. Water suppliers will need to identify their wells by attaching a well identification plate to the well. This needs to be done before November 1, 2006.

Standards for floodproofing will apply to all community wells to prevent direct entry of floodwaters into the well.

The increased cost for drilling, and ultimately closing, a new community well is expected to be approximately 5% - 10% of the current cost of the well. These added costs are primarily for installing a surface seal and for closing a well at the end of their useful life. There are also requirements for on-going maintenance of the well and well head and capping or covering the well.

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How will the Ground Water Protection Regulation affect industry professionals?

The GWPR affects well drillers, well pump installers and qualified professionals (Professional Engineers and Professional Geoscientists) working in the ground water, environmental and geotechnical engineering field. Industry professionals should be aware of their new responsibilities under the GWPR. To help them learn what is expected, training workshops, guidebooks and other information will be provided over the next year through the British Columbia Ground Water Association and the Ministry s Ground Water Home Page.

How will the Ground Water Protection Regulation affect First Nations?

Any increase in costs for well construction, operation and maintenance to comply with the new Ground Water Protection Regulation will be the same on or off reserves / treaty settlement lands. See impacts on Individual Well Owners and Community Wells.

How was the Ground Water Protection Regulation developed?

The GWPR is based on recommendations made by the Ground Water Advisory Board, an expert panel of ground water scientists and engineers and representatives of the well industry. As such, the recommendations help ensure the GWPR is practical and science-based.

Targeted consultation on the GWPR was held with 21 external stakeholder groups in the spring of 2003 including:

- British Columbia Ground Water Association,
- British Columbia Water and Waste Association,
- five British Columbia Health Authorities, and

- Union of British Columbia Municipalities.

The overwhelming response has been that ground water regulations are long over-due. Reaction of targeted stakeholders to the GWPR has been positive. Industry has long been calling for the "level playing field" the GWPR will provide and other stakeholders encourage government to go further and move on to the development of Phases two and three.

Previously, a broad-based consultation with the general public (including well owners) was undertaken in spring 2001 on the then proposed Drinking Water Protection Act, including the new ground water protection provisions.

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Frequently Asked Questions about the Ground Water Protection Regulation

Q: What is covered by the GWPR?

A: The GWPR will be completed in three phases.

Phase 1 covers:

- qualifications for well drillers and well pump installers,
- a register for qualified well drillers and well pump installers,
- ground water protection through flood proofing, surface sealing, well caps and covers, protection of the well head, and deactivating or closing of wells (well construction standards), and
- well identification.

Phase 2 will focus on:

- additional standards for well construction, flowing wells, well pumps, flow testing and well operation,
- water analysis for new and altered wells,
- well reports, and
- the establishment of offences for which tickets may be issued.

Phase 3 will focus on:

- implementing water management plans in designated areas,
- drilling authorizations (if necessary), and
- other measures for aquifer quality and quantity protection and use.

The GWPR applies to water supply wells (i.e., domestic wells and non-domestic wells, such as irrigation wells), ground water monitoring wells, recharge and injection wells, dewatering or drainage wells, remediation wells and geotechnical wells that do not involve water transfer (i.e., boreholes, test pits, closed geo-thermal and special types of holes). The GWPR does not apply to geothermal wells, oil and gas wells, or wells used for coalbed methane extraction which are already regulated under other acts, like the *Geothermal Resources Act*, *Mines Act*, and *Petroleum and Natural Gas Act*.

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Q: Why is the GWPR needed?

A: Unregulated drilling activities and lack of enforceable well construction standards have contributed to ground water quantity and quality problems in some areas of BC. These problems could potentially affect human health, public safety and property values.

This is the first time that British Columbia has enacted ground water protection regulations. Prior to enacting the GWPR, British Columbia was the only province in Canada without comprehensive ground water regulations.

Q: What is the purpose of the Ground Water Protection Regulation(GWPR)?

A: The primary purpose of the Ground Water Protection Regulation is protection of the quantity and quality of the province s valuable ground water resource by:

- setting out standards to safeguard and maintain the integrity and efficient use of the ground water resource, and
- ensuring activities related to well water and ground water are undertaken in an environmentally safe manner.

Q: How was the GWPR developed?

A: The GWPR is based on recommendations made by the Ground Water Advisory Board, an expert panel of ground water scientists and engineers and representatives of the well industry. As such, the recommendations help ensure that the GWPR is practical and science-based.

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Q: With whom did the government consult on the GWPR?

A: Targeted consultation on the GWPR was held with 21 external stakeholder groups in the spring of 2003 including:

- British Columbia Ground Water Association,
- British Columbia Water and Waste Association,
- five British Columbia Health Authorities, and
- Union of British Columbia Municipalities.

Previously, a broad-based consultation with the general public (including well owners) was undertaken in Spring 2001 on the then proposed *Drinking Water Protection Act*, including the new ground water protection provisions.

Q: What was the response of consulted stakeholders to the GWPR?

A: The benefits are:

- securing a safe and healthy ground water resource and reducing risk of degradation of water quality and depletion of aquifers,
- increased public confidence in ground water resources,
- improved integrity and safety of wells and community drinking water supplies (consumer protection),
- consistent province-wide performance standards for well drillers and well pump installers (level playing field),
- improved tracking of wells and their condition,
- a system of ground water protection that is efficient and accountable,
- clearer responsibility of well owners to maintain wells in safe and sanitary condition, and
- enhanced protection of aquatic ecosystems dependent on ground water.

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Q: How does the GWPR stack up against similar ground water regulations in other provinces or states?

A: The GWPR addresses critical issues that Alberta, Ontario and Washington State have also addressed: qualifications of the people who do the work, surface sealing of wells, closing of wells and flood-proofing of drinking water supplies.

Q: Doesn't the Drinking Water Protection Regulation (DWPR) already protect ground water?

A: The Drinking Water Protection Regulation does not directly address private domestic wells. The GWPR compliments the DWPR by providing protection to private domestic wells (as well as community wells) by addressing standards for well construction and operation. Standards for well construction and operation in the GWPR also apply to wells used for non-domestic water supply and other purposes.

Q: Why is the Provincial Government adopting the GWPR in phases?

A: We are adopting the GWPR in phases because:

- the scope of the legislation is sufficiently broad
- phasing allows us to gain experience over a short period of time to develop the rest of the GWPR.

Q: When will Phase 1 of the GWPR come into effect?

A: Phase 1 of the Ground Water Protection Regulation will begin to come into force on November 1, 2004 (registration provisions). The remainder of the Phase 1 GWPR (well construction standards) will come into force on November 1, 2005, thereby allowing an additional year of transition for individual well owners, industry and municipalities.

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Q: When will Phase 2 and 3 of the GWPR come into effect:

A: Work on the first elements of Phases 2 and 3 started in the fall of 2003 and are still in development.

Q: Do the drilling standards in the GWPR apply to all wells?

A: No, geothermal wells, oil and gas wells, and wells used for coalbed methane gas extraction are already regulated under other acts, like the *Geothermal Resources Act*, *Mines Act*, and *Petroleum and Natural Gas Act*, and will not be regulated under the GWPR. The GWPR applies to all other wells, however.

Q: Is there flexibility in the drilling standards?

A: Yes, the GWPR does provide flexibility for some standards (e.g., surface seals) by allowing alternative specifications to be approved by the province or by a Professional Engineer or Professional Geoscientist with expertise in ground water.

Q: Why do we need to have qualified well drillers and well pump installers operating in the province?

A: Although this province has some of the best water well drillers in the world, unregulated drilling activities and lack of enforceable construction standards have contributed to ground water quantity and quality problems in some areas of the province. Improperly and poorly constructed wells and test holes can become pathways for contamination of aquifers and drinking water supplies. Having only qualified drillers and well pump installers work in the province will minimize these problems and provide greater protection to well owners.

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Q: Why are abandoned wells a concern?

A: Prior to the GWPR, there were no requirements for wells that are no longer in use to be filled and closed. In addition to the dangers of people and animals falling in excavated wells, these and other wells provide a conduit for contamination to enter directly into the underlying aquifer through the well, degrading the water quality and impacting other well users.

Q: Why is it necessary for wells to have a surface seal?

A: Bacteriological contamination of private domestic wells is a problem in many local areas of the province. This can be minimized or eliminated by installing surface seals in wells to effectively prevent contaminated water from the surface or shallow subsurface zone from entering the well and the aquifer.

Q: Why is it necessary to cap or cover my well?

A: It is necessary to cap or cover your well in order to prevent any contaminants or contaminated flood waters from directly entering the well at the wellhead. For large diameter excavated wells, it is also necessary to cap or cover them as a safety precaution to prevent persons or animals from falling into the well.

Q: Why is it necessary to identify wells with a Well ID plate?

A: It is often difficult to distinguish one well from another in the field. Identifying a well in the field with a well identification plate allows verification of the well to the well record.

Q: Who is affected by the GWPR?

A: Owners of all new and pre-existing wells should be aware of their new responsibilities under the GWPR. Also affected by the GWPR are well drillers, well pump installers and qualified professionals (Professional Engineers and Professional Geoscientists) working in the ground water, environmental and geotechnical engineering field, as well as developers who require geotechnical, monitoring or dewatering wells.

The GWPR will also affect the duties of various government officials under the *Water Act* and *Drinking Water Protection Act*.

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Q: I had a well drilled over 10 years ago, do the new standards apply to my well?

A: Yes and no. For example, the requirement for installing a well cap applies to both new and existing wells, while other requirements such as well identification applies to new and existing community wells but not existing private water supply wells.

Standards for well deactivation or closure also apply to existing wells. Certain standards for well construction may be triggered for an existing well if it is altered. Talk to your local well driller or well pump installer and consult the GWPR.

Q: What cost increases can an individual private well owner expect?

A: For a typical existing water supply well, the cost to the well owner is primarily for closing the well at the end of its useful life (~6% of the cost for a current well). For new water supply wells, the added costs are primarily for the surface seal and for closing the well at the end of its useful life (~10% of the cost for a current well).

The financial costs are considered acceptable for protecting the well supply and ground water resource.

Q: Does the GWPR mean water well licensing and fees?

A: No. Wells regulated under the GWPR are not licensed, nor does the province charge any fees or rentals for extraction of ground water.

Q: How will the GWPR affect the well drilling industry?

A: The GWPR helps ensure a level playing field by providing minimum well construction standards that every driller must meet. The GWPR affects well drillers and well pump installers. Industry professionals should be aware of their new responsibilities under the GWPR. Training workshops, guidebooks and other information will be provided through the British Columbia Ground Water Association and through the Ground Water Home Page.

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Q: How does a well driller or well pump installer become qualified so they can get their name on the register?

A: A well driller or well pump installer will need to apply to the province to become registered. Through the application process, they will have to show their qualifications and experience. Once they adequately demonstrate this, they will be registered and be provided with an identification card.

Q: When can well drillers or well pump installers begin to apply to the province to become registered?

A: Authority to adjudicate applications will come into effect with the GWPR on November 1, 2004. Applications received prior to November 1, 2004 will be held by the Ministry until they may be officially adjudicated under the authority of the GWPR.

Prior to November 1, 2004, the Ministry of Water, Land & Air Protection will be developing and making available registration application forms for use by well drillers and well pump installers.

Q: Do I also need to have qualifications if I drill monitoring wells or geotechnical boreholes?

A: In general, any person who constructs a well regulated under the GWPR is required to be qualified, including persons who construct monitoring wells. A person is not required to have qualifications for constructing a geotechnical well if the well is not likely to disturb or does not disturb an aquifer. A person is not required to have qualifications for excavating a well of 15 m depth or less.

In cases where a qualified well driller is not required, the well construction standards (e.g., standards for surface sealing, capping, protection of the well head) will still apply.

Q: Does the GWPR have grand-parenting provisions for well drillers and well pump installers?

A: Yes, well drillers and well pump installers who are currently not certified by the province s Industry Training Centre or by the Canadian Ground Water Association can be grand-parented, provided they can demonstrate that they have the equivalent of 5 years full time experience drilling wells or installing well pumps. The grand-parenting provision will end on October 31, 2006.

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Q: How will someone know if a well driller or well pump installer is qualified?

A: As a requirement of the GWPR, the Ministry must keep a register of qualified well drillers and a register of qualified well pump installers who are authorized to operate in the province. These registers will be made publicly available likely on the internet.

Registered well drillers and well pump installers will be issued an identification card as proof of their qualifications.

Q: Will costs to well drillers and well pump installers increase because of the GWPR? If so, by how much?

A: The GWPR is not expected to increase costs to well drillers or well pump installers.

Q: With all these new regulations, how will drillers and pump installers know what is expected?

A: Training workshops, guidebooks and other information will be provided through the BC Ground Water Association and through the Ministry Ground Water Home Page.

Q: How will the province enforce the new regulation?

A: Because this is a health and safety issue, we expect high degree of voluntary compliance. We ll be raising awareness through education, guidebooks and brochures, as well as training workshops with industry. There will be general and ticketable offences for non compliance. We will focus our enforcement efforts where we know there is non-compliance or where there is a high-risk to the aquifer or to public health and safety.

Q: What are some of the non-compliance offences and fines?

A: Among the offences are: tampering with a well; failure to deactivate or close an unused well; failure to provide proof of qualifications; introducing waste into a well.

Details of ticketable offences and fines are still in development and will be addressed in Phase 2 of the GWPR.

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Q: Will Ministry staff be going onto people's property to check compliance?

A: The Ministry will rely heavily on voluntary compliance. We will focus our enforcement efforts where we know there is non-compliance or where there is a high-risk to the aquifer or to public health and safety.

Q: What else is the Ministry of Water, Land and Air Protection doing to enhance the management and protection of ground water?

A: In addition to the GWPR, the Ministry of Water, Land and Air Protection has always had a strong tradition of promoting ground water management and protection through non-regulatory means.

The ministry continues to map and classify developed aquifers in the province. To date, the ministry has identified and classified over 600 aquifers in BC and hopes to complete the inventory by 2010. The ministry is also beginning to map in detail, high priority aquifers in the province.

The Ministry is also supporting workshops on ground water protection and monitors ambient ground water levels and ground water quality in developed aquifers throughout the province through its Observation Well Network and Ambient Ground Water Quality Monitoring Network.

Important Links

The registration provisions in the Ground Water Protection Regulation and amendments to the *Water Act* relating to ground water will come into force on November 1, 2004, and the remainder of the Regulation, including Appendix A (the Code of Practice for Construction, Testing, Maintenance, Alteration and Closure of Wells in British Columbia) which sets out the minimum rules or standards in relation to wells will come into force on November 2005.

The legislation is located on the following web pages:

Ground Water Protection Regulation

Amendments to the *Water Act* (2001) (see sections 87-101 of Bill 20)

Existing *Water Act*

The consolidated version of the *Water Act* (i.e., with amendments included) will be in effect on November 1, 2004. A link will be provided from this site to the consolidated *Water Act* shortly thereafter.

Would you like more information on the Ground Water Protection Regulation?

If you have further questions or would like more information about the Ground Water Protection Regulation, please write to:

Water Protection Section
Water, Air and Climate Change Branch
Ministry of Water, Land and Air Protection
PO Box 9341 Stn Prov Govt
Victoria BC V8W 9M1

Fax: (250) 356-7197
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Mathematical Logarithms

The huge ranges of seismic wave amplitudes, seismic moments, atmospheric energies, and other physical quantities is a problem. It would be much easier to communicate the energies or moments of earthquakes to the public on a simple scale that just ranges about from one to ten.

To turn these astronomical ranges into a simple scale, we can use the mathematical device of the **logarithm**. If we raise ten to some power *x* to make a big number *N*, then the **log** of that big number *N* is the power *x*:

$$10^x = N \qquad \log_{10} N = x$$

Now let's review the **log** (base 10) of some example numbers:

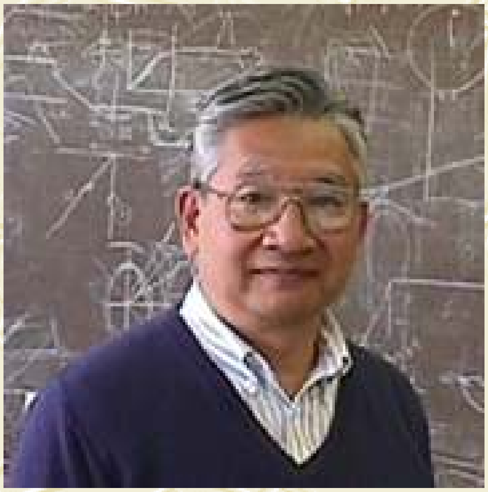
N	$x = \log N$
10	?
1	?
100	2
1×10^{25}	25
25	(1-2, ~1.4)
0.01	-2
-1	undefined

Note that while you can take the log of a very small number, which will be negative, you can't take the log of any **negative** number.

J. Louie, revised 29 June 1998

Back to: Richter Magnitude
Previous: Seismic Waves --- Next: Earthquake Effects in Kobe, Japan

Hiroo Kanamori



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RESEARCH

Physics of Earthquakes

During an earthquake, one side of the fault moves suddenly with respect to the other. This process radiates energy as seismic waves, and generates heat due to friction and other non-linear processes. The study of the recent deep Bolivian earthquake suggests that only 4 % of the total strain energy was released as seismic waves, and most of the energy was converted to heat. The total amount of heat energy released is 1 to 10 times more than that released during the major volcanic eruptions such as the 1980 Mt St Helens eruption. This result suggested that melting can be an important mechanism for promoting seismic slip, especially for deep-focus earthquakes.

With the advent of modern broad-band seismic networks we can study seismic wave radiation in detail, from which we can understand how an earthquake nucleates, ruptures, and stops. The goal is to understand the deterministic as well as "complex" aspect of earthquake physics.

- *Kanamori, H., and M. Kikuchi, The 1992 Nicaragua Earthquake: a slow tsunami earthquake associated with subducted sediments, Nature, 361, 714-716, 1993.*
- *Kikuchi, M., and H. Kanamori, The mechanism of the deep Bolivia earthquake of June 9, 1994, Geophys. Res. Lett, 21, 2341-2344, 1994.*
- *Kanamori, H., D. L. Anderson, and T. H. Heaton, Frictional melting during the rupture of the 1994 Bolivian earthquake, Science, 1998.*

Interaction of Atmosphere and Lithosphere

The earth's surface is covered by atmosphere, and energy coupling occurs between atmosphere and lithosphere. For example, during the major eruption of Mount Pinatubo in the Philippines on June 15, 1991, an unusually long (at least two hours) seismic wave train having periods of about 230 sec was recorded at seismic stations throughout the world. This oscillation has a very sharp spectral peak at a period of 228 sec. We found that this wave train is the seismic Rayleigh wave excited by atmospheric oscillations near the volcano that were set off by continuous thermal energy flux from the volcano. This study demonstrated that modern seismological networks can be used to study the physics of volcanic eruptions; it provides new information about how volcanoes affect the Earth's atmosphere and a way to quantify volcanic eruptions. Study of acoustic and gravity waves has interesting applications for understanding unusual waves excited by space shuttles and the impact of the Shoemaker-Levy comet.

- *Kanamori, H., J. Mori, D. Anderson, and T. Heaton, Seismic Excitation by the Space Shuttle Columbia, Nature, 349, 781-782, 1991.*
- *Kanamori, H., and J. Mori, Harmonic Excitation of Mantle Rayleigh Waves by the 1991 eruption of Mount Pinatubo, Philippines, Geophys. Res. Lett., 19, 721-724, 1992.*
- *Kanamori, H., Excitation of Jovian normal modes by an impact source, Geophys. Res. Lett., 20, 2921-2924, 1993.*
- *Ingersoll, A. P., and H. Kanamori, Waves from the collisions of Shoemaker-Levy 9 with Jupiter, Nature, 374, 706-708, 1994.*
- *Kanamori, H., J. Mori, and D. G. Harkrider, Excitation of atmospheric oscillations by volcanic eruptions, J. Geophys. Res., 99, 21,947-21,961, 1994.*

Application of Real-Time Seismology to Hazard Mitigation

Advances in seismic sensor and data acquisition systems, digital communications, and computers make it possible to build reliable real-time earthquake information systems. Such systems provide a means for modern urban regions to cope effectively with the aftermath of major earthquakes. While accurate earthquake predictions are difficult, these systems aid in the post-earthquake response and recovery phases, and thus are socially beneficial in modern industrialized urban and suburban regions. In the long term these systems also provide basic data for mitigation strategies such as improved building codes. We are developing a modern seismic network, TriNet, to accomplish this goal. TriNet is a joint project between Caltech, U.S. Geological Survey, and the State of California.

- *Kanamori, H., Locating Earthquakes with Amplitude: Application to Real- Time Seismology, Bull. Seismol. Soc. Am., 83, 264-268, 1993.*
- *Kanamori, H., E. Hauksson, and T. Heaton, Real-time seismology and earthquake hazard mitigation, Nature 390, 461-464, 1997.*

Physics of Long-Term Crustal Processes Associated with Earthquakes

The physical properties of the Earth's crust are likely to change as a function of time. However, physics of such changes is not well understood. For example, after the 1992 Landers, California, earthquake, seismic activity in many places in California increased significantly. One interpretation is that the strength of crust was suddenly reduced when it was shaken by passing seismic waves from the Landers earthquake. We have explored a mechanism for such weakening. Although this field is at an early stage of development, a better understanding of the physics of fluid-filled crust would lead to unraveling many interesting, but mysterious, phenomena associated with earthquakes. These phenomena include changes in seismicity, seismicity patterns, electric-magnetic field disturbances, and changes in ground-water level and chemistry.

- *Sturtevant, B., H. Kanamori, and E. Brodsky, Seismic triggering by rectified diffusion in geothermal systems, J. Geophys. Res.. 101, 25269, 1996.*

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CURRICULUM VITAE

Personal
Born -17 October 1936
Japan (Japanese citizen)

Education
B. S. (Physics), Tokyo University, 1959
M. S. (Geophysics), Tokyo University, 1961
Ph.D. (Geophysics), Tokyo University, 1964

Professional Experience
Research Associate, Geophysics Institute, Tokyo University, 1962-65
Research Fellow, California Institute of Technology, 1965-66
Associate Professor, Earthquake Research Institute, Tokyo University, 1966-69
Visiting Associate Professor, Massachusetts Institute of Technology, 1969
Professor, Earthquake Research Institute, Tokyo University, 1970-72
Professor, California Institute of Technology, 1972-89
Director, Seismological Laboratory, California Institute of Technology, 1990-April, 1998
John E. and Hazel S. Smits Professorship of Geophysics, 1989-

Major Research Interest
Kanamori's research centers on the physics of earthquakes. His work includes: (1) quantification of great earthquakes using Mw scale, (2) quantitative study of tsunami earthquakes, (3) seismological study of volcanic eruptions, (4) real-time seismology for hazard mitigation, (5) study of atmospheric waves excited by volcanic eruptions, (6) study of interaction between solid earth and atmosphere, (7) frictional melting due to faulting, (8) synthesis of microscopic and macroscopic physics of earthquakes.

Membership
Seismological Society of Japan
American Geophysical Union

Seismological Society of America
Earthquake Engineering Research Institute
American Academy of Arts and Sciences

Awards and Honors

President of the Seismological Society of America, 1985-86; Chairman, Committee on Seismology, National Research, Council, National Academy of Sciences, 1986-1989; Member of the American Academy of Arts and Sciences, 1987- ; Medal of the Seismological Society of America, 1992; Arthur L. Day Prize and Lectureship, National Academy of Science, 1993; California Scientist of the Year, Museum of Science and Industry Award, 1993; The Asahi Prize, 1993; Walter H. Bucher Medal, American Geophysical Union, 1996

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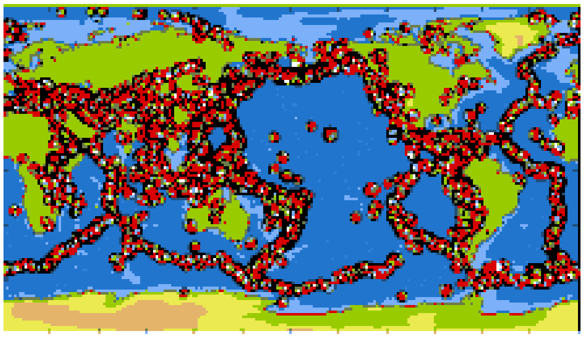


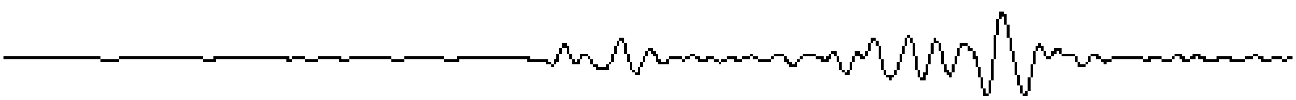
Harvard Seismology: Centroid-Moment Tensor Project

Centroid-Moment Tensor (CMT) solutions are produced on a routine basis for events with moment magnitudes (M_W) greater than about 5.5. CMT solutions are published quarterly in *Physics of the Earth and Planetary Interiors*; you can access the CMT Catalog from here as well. **Quick CMTs** are produced in near-real time, and distributed to interested parties via email; you can also view a map of recent quick CMTs. If you would like to be included in the distribution list for Quick CMTs, send us email.

You can view a gallery of figures related to the CMT project.

Active participants in this project are Adam Dziewonski, Göran Ekström, Natasha Maternovskaya, Michael Antolik and Meredith Nettles.

The Harvard CMT Project is supported by the National Science Foundation grant EAR-9805172.



- **New York earthquake, April 20, 2002: map with CMT focal mechanisms**

Recent Developments

- We have extended the CMT analysis to smaller earthquakes by analyzing teleseismic intermediate period surface waves (Arvidsson and Ekström, 1998).
- We have analyzed the larger earthquakes in the 1997 Umbria-Marche (central Italy) sequence using a new method of surface wave CMT analysis (Ekström et al., 1998).
- CMT solutions have been produced for large (M_w > 6.0) events of 1976, using recalibrated data from the High Gain Long Period seismographic network (Ekström and Nettles, 1997).

Publications

- The CMT method is described in several key references.
- CMT solutions are presented in several papers, and for events in or after 1982, are reported quarterly in *Physics of the Earth and Planetary Interiors*.
- 1976 CMT solutions

John N. Louie, Ph.D.

Contact -- Goals -- Classes -- Papers -- Commercial -- Free Software! -- Research -- More...

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The goal of my research is to accurately image and characterize subsurface structures in seismically difficult areas, with high-resolution experiments. I constrain these inversions with independent geophysical and geological data. The seismic imaging, tomography, and monte-carlo optimization techniques I develop improve the productivity of resource exploration and development,

John is a faculty member of the Nevada Seismological Laboratory and the Dept. of Geological Sciences in the Mackay School of Earth Sciences and Engineering, College of Science at the University of Nevada, Reno.

and of hazards assessments. In particular I try to describe the characteristics of earthquake faults and of sites in order to mitigate seismic hazards to life and property.

Key Words: geophysics, seismology, resource exploration and development, seismic reflection, geophysical imaging and inversion, tomography, modeling, scientific visualization, earthquake hazards, tectonics.

- John **teaches**:
  - Geol 492/692, **Applied Geophysics**, next offered Spring 2005 (merges 453/653 with 492/692).
  - Geol 706, **Geophysical Series and Filtering**, #85831, *Mondays and Wednesdays 9:30-10:45 in LMR 355*, now offered Spring 2004 (after combination with easier parts of 757). Interactive exercises in Java.
  - Geol 757, **Seismic Imaging**, may be offered Fall 2006 (after combination with harder parts of 706).
  - Class resources for **geophysical field work**.
  - Geol 702H or 702V, Scientific Visualization Seminar and Workshop, no longer offered but resources still on line.

  John also helps teach:
  - Geol 701V, **Surface Waves, Crustal Structure, and Tomography**, a new offering by Louie, Brune, Zeng for Fall 2004.
  - Geol 100, **Earthquakes, Volcanoes, and other Natural Disasters**, taught by Louie Fall 2003.
  - Geol 101, **General Geology I (Physical Geology)**, taught by Louie Fall 1999.
  - Geol 203, Seismic stratigraphy lectures and lab in **Earth Surface Processes and Deposits** .
  - Geol 333, **Structure, Tectonics and Earth Physics II** offered each Spring by Karlin.
  - Geol 455/655, **Geophysics and Geodynamics**, next offered Fall 2004 by Anderson.
  - Geol 456/656, Plate Tectonic Theory, no longer offered, portions revised into Geol 332/333.
  - Geol 492/692, Environmental Exploration Geophysics (Hydrogeophysics), next offered Spring 2005 as Applied Geophysics.

  Contact -- Goals -- Classes -- Papers -- Commercial -- Free Software! -- Research -- More...

- John's **recent papers** are:
  - Weston Thelen, Jim B. Scott, Matthew Clark, Craig M. dePolo, and John N. Louie, 2004,

Geophysical investigation of recent faulting in the east Gardnerville Basin: submitted to the *XVI INQUA Congress Special Paper on Paleoseismology*, Geol. Soc. Amer., Boulder, Colo., June 30. (2.7 Mb PDF)

- John N. Louie, Aasha Pancha, Glenn P. Biasi, Weston Thelen, James B. Scott, Mark F. Coolbaugh, and Shawn Larsen, 2004, Tests and applications of 3-d geophysical model assembly: submitted to *Geophys. Res. Lett.*, June 7. (644 kb PDF)
- Weston A. Thelen, Matthew Clark, Christopher T. Lopez, Chris Loughner, Hyunmee Park, James B. Scott, Shane B. Smith, Bob Greschke, and John N. Louie, 2004, A transect of 200 shallow shear velocity profiles across the Los Angeles Basin: submitted to *Bull. Seismol. Soc. Amer.*, May 5. (2.7 Mb PDF)
- J. B. Scott, M. Clark, T. Rennie, A. Pancha, H. Park and J. N. Louie, 2004, A shallow shear-wave velocity transect across the Reno, Nevada area basin: submitted to *Bull. Seismol. Soc. Amer.*, 7 Oct. 2003, revised June 15.
- John N. Louie, Weston Thelen, Shane B. Smith, Jim B. Scott, Matthew Clark, and Satish Pullammanappallil, 2004 in press, The northern Walker Lane refraction experiment: Pn arrivals and the northern Sierra Nevada root: *Tectonophysics*, submitted 2 July 2003, revised Dec. 14, accepted July 10. (4.1 Mb PDF)
- John N. Louie, Sergio Chávez-Pérez, Stuart Henrys, and Stephen Bannister, 2002, Multimode migration of scattered and converted waves for the structure of the Hikurangi slab interface, New Zealand: *Tectonophysics*, *355*, no. 1-4, 227-246.
- Ken Mela and John N. Louie, 2001, Correlation length and fractal dimension interpretation from seismic data using variograms and power spectra: *Geophysics*, *66*, 1372-1378. (2.6 Mb PDF)
- John N. Louie, 2001, Faster, better: shear-wave velocity to 100 meters depth from refraction microtremor arrays: *Bull. Seismol. Soc. Amer.*, *91*, no. 2 (April), 347-364.
- R. E. Abbott, J. N. Louie, S. J. Caskey, and S. Pullammanappallil, 2001, Geophysical confirmation of low-angle normal slip on the historically active Dixie Valley fault, Nevada: *Jour. Geophys. Res.*, *106*, 4169-4181. (1.1 Mb PDF)
- Z. Kanbur, J. N. Louie, S. Chavez-Perez, G. Plank, D. Morey, 2000, Seismic reflection study of Upheaval Dome, Canyonlands National Park, Utah: *Journal of Geophysical Research (Planets)*, *105*, 9489-9505.
- Robert E. Abbott and John N. Louie, 2000, Depth to bedrock using gravimetry in the Reno and Carson City, Nevada area basins: *Geophysics*, *65*, 340-350.

* John works closely with Optim LLC, a Nevada software company that has partnered with the University through the Nevada Applied Research Initiative (NARI). Optim is the principal supporter of the Center for Migration and Tomography (CEMAT) and the Collaboratory for Computational Geosciences (CCoG) at UNR. Their commercial products include:
  - **SeisOpt®ReMi™**: Refraction Microtremor for Shallow Shear Velocity
  - **SeisOpt®@2D™**: Refraction Velocity Anaysis for Engineering
* **Free Software!** John offers to geophysicists and students:
  - **The Resource Geology Seismic Processing System for Java (JRG)** is a basic reflection processing package with superb graphics, 3-d and crooked-line capabilities, SEG-Y and sound file I/O, and a friendly GUI that runs on any machine (lacks muting, decon, migrations): JRG home - download (240 kb .jar) (run ``java -cp jrg.jar Viewmat") - download source (172 kb .jar) - class exercises using JRG: refraction; reflection; complex numbers; 2-d FFT; wave propagation - sound and image output examples.

- **ModelAssembler** is an open-source, Java-based velocity-model gridding code that can integrate scattered and heterogeneous geophysical data sets. The version 3.0 distribution includes basin data files for the Great Basin (12.6 Mb compressed tar archive). MA3 and the E3D finite-difference code were used on the CCoG facility in lab exercises for a Fall 2002 Geophysics and Geodynamics course to explain: f-d synthetic seismograms; the Courant condition; grid dispersion; Huygens, Fermat, and Snell. More on Shawn Larsen's E3D code from: the OECD's Nuclear Energy Agency; LLNL's Hazards Mitigation Center.
- **AssembleTexans** is a Java code, that will run on an RT-125 bridge computer, and make gathers out of .RSY files by simple concatenation that JRG will view: download source (.java); download compiled .class.
- **The Resource Geology Seismic Processing System (RG)** is a collection of 150 (mostly) simple C codes for seismic processing research, without support for graphics or standard headers: package documenting how to migrate network seismograms; more about RG; program list; download source & Sun binaries (4+ Mb .tar.Z); Clayton's getpar (required); exercise using RG.
- **Getpar for Java** implements some of the features of Clayton's library: source [main() is usage examp.]; tests.
- **Grav2d** is a simple Talwani-prism gravity inversion, in Java so it runs on anything, with no GUI and simple text input and output: download source (.java); class exercise.
- **Surv** is a C code that reduces data collected with an EDM theodolite: download source (.c); usage examples.
- **Fttest** is a C code for a 2-d FFT benchmark: download directory; cross-platform results.

- John's **research projects** include:
  - **The Center for Migration and Tomography** (CEMAT) and **The Collaboratory for Computational Geosciences** (CCoG)
    - Earthquake Hazard Surveys Across Urban Basins (so far: Reno, Los Angeles, Las Vegas)
    - LLNL Cooperative Research: 3-D Evaluation of Ground-Shaking Potential in the Las Vegas Basin
    - Research to Increase Utilization of Geothermal Resources in the Western United States: Assembly of a Crustal Seismic Velocity Database for the Western Great Basin
    - Evolution of the Sierra Nevada - Basin and Range boundary -- tephrochronologic and gravity constraints on the record in Neogene basin deposits
    - Geophysical Test of Low-Angle Dip on the Seismogenic Dixie Valley Fault, Nevada
    - Imaging a Subduction Interface With Local-Earthquake Seismograms, Hikurangi Margin, New Zealand
    - Geophysical Surveys of the Upheaval Dome Impact Structure, Canyonlands National Park, Utah
    - Geophysical Constraints on Extensional Models for the Death Valley Region of California and Nevada
    - The Resource Geology Seismic Processing System for Java
  - The Sound of Seismic
  - Site Response to LARSE-2 Blasts at Precarious Rock Sites Near the SAF
  - Seismic Hazards in the Reno Area

- Reflectivity Structure Below the San Fernando Valley from Northridge Aftershock Recordings

- Read John's **curriculum vita** (with links), or a 2-page resume in PDF or Word RTF format.
- Presentation on Applied Geophysics at the Mackay School of Mines.
- **Photos:** Aerial Geology; geology/geophysics/tectonics thumbnail collection index and archive; higher-res geophysical photos; class fieldwork albums.
- During work hours (9-5 M-F) you can go to John Louie's Web server on his personal Macintosh. This is the home of John Louie's Road Flights page, with time-lapse movies of scenic drives in California and Nevada. *9-5 Mon.-Fri. (and some weeknights) ONLY*
- Additional information may be available through `http://home.netcom.com/~jnlouie`

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Benjamin John Louie was born at 3:22 PM on August 8, 1995.

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Nevada Seismological Laboratory Feature

NSL and NBMG scientists observed a probable magmatic event below North Lake Tahoe in late 2003. This slow event was inferred from a cluster of 1600 deep crustal microearthquakes and a small (~1 cm) displacement of Slide Mountain where a permanent geodetic station is installed. The magmatic event is thought to lie approximately 30 km (20 miles) below the surface and stopped abruptly in January of 2004. Details of this study can be found in a *Science Magazine* article just published. Read the press release...

What's New

July 27, 2004: New site design implemented!

2004-08-29

Earthquake Information

- Past Earthquakes
- Current Activity
- Future Hazards

Earthquake Preparedness

- Living with earthquakes in Nevada
- Earthquakes in Nevada & how to survive them
- K-12 Educational Seismic Network
- More

Search the NSL: Go!

Upcoming Events

2005 Seismological Society of America Annual Meeting
April 27 - 29, 2005
Incline Village, Nevada

UNR students needed to help with field work in August. Valid drivers license and/or backcountry experience a plus. Email jscott@seismo.unr.edu for more info.

Want to know more?

Then visit our Announcements Page!

Nevada Seismological Laboratory
Site Design by: Fiona Jane F. Orolfo.
Site Last Modified on 8/6/04

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Español | Research Projects | Earthquake Preparedness | Earthquake Information | Links
Site best viewed with Internet Explorer 4.0+ with 800 x 600 resolution
University of Nevada, Reno

An Explanation of my symbol for Bad Science

It is better to communicate good information than to offer misinformation in the name of good communication.

ABF

*T*his is an image of a raindrop as presented by popular culture. Actually, real raindrops do not look like this (until they have ceased to be rain by splattering on a window, say). Small raindrops are spherical; larger ones assume a shape more like that of a hamburger bun. Of this there is no question. A more detailed discussion of this can be found on the Bad Rain page. (Green might seem like an odd choice as the color of rain, but it follows a long-standing meteorological convention --- see radar maps for an example. However, it does not seem likely that anyone will be misled by this color coding into believing that rain is, in fact, green.)

*Y*et, everything from advertisements to (gulp) The Weather Channel, artistically represents raindrops as teardrops. I once asked a television weatherman why he did this despite the fact that he (presumably) knew better. "Because," he responded, "it is good communication." Sigh... This page is dedicated to the proposition that:

> *it is better to communicate good information than to offer misinformation in the name of good communication.*

Be very, very careful what you put into that head,
because you will never, ever get it out.
Thomas Cardinal Wolsey (1471-1530)

Bad Science

Click on the symbol for its explanation.

Preamble

*T*his page is maintained by Alistair B. Fraser in an attempt to sensitize teachers and students to examples of the *bad science* often taught in schools, universities, and offered in popular articles and even textbooks.

*H*ere, I explain what I mean by bad science and provide pointers to specialized pages on bad science within various disciplines. In particular this page points to Bad Meteorology , a page also maintained by Alistair B. Fraser.

This site accepts no requests for reciprocal links, even if those requests come in the form of a supposed award. Editorial decisions will not be influenced by requests for such *quid pro quo* arrangements.

However, it will gladly link to other sites which explore the same pedagogical isues of bad science.

*W*hen I created this page, in January, 1995, I naïvely expected that other frustrated teachers would rush to build sites devoted to, say, Bad Archeology and Bad Biology. It has not happened. Apparently, most teachers believe everything they teach. Sigh, one is reminded of Lily Tomlin when she said , “No matter how cynical you become, it's never enough to keep up.”

*T*he *Bad Science* and *Bad Meteorology* pages have been cited by over 3000 other web pages, and in books, magazines, and on TV.

What is Bad Science?
(at least within the context of this page)

> *B*ad Science abounds and comes in many guises. This page sets out to attack only one brand: well understood phenomena which are persistently presented incorrectly by teachers and writers, presumably because they either do not know any better or because they don't really care enough to get it correct. By publicizing examples of bad science, I hope to sensitize students, teachers and writers to the horrors of such glib explanations or representations.

What this page is NOT about.

*F*or the purposes of this page, bad science does not mean pseudo-science. I realize that the boundary is permeable, but there is a useful distinction. The practitioners of (what scientists refer to as) pseudo-science generally know and even understand established scientific thought; they just reject it (for reasons which may have little to do with science itself). Treatments of pseudo-science and the paranormal are well treated elsewhere. See, for example, the Skeptical Inquirer , or the Skeptics Society . By way of contrast, purveyors of bad science are generally teachers or writers who just don't know any better.

Study finds errors rife in Science textbooks

This study goes well beyond bad science to include bad editing and the disingenuousness textbook committees who are more interested in using science textbooks as a vehicle for political correctness than scientific correctness.

A copy of the study is available: Review of Middle School Physical Science Texts

*S*imilarly, this page does not address contemporary controversies, about which the experts are still in active debate. Rather, it concerns itself with ideas and facts which are well established and well understood, but which persist in being presented incorrectly.

*A*s such, this page is about teaching rather than research.

The difficulty with science education is that so much of it is actually reeducation.

I find teaching of science fairly easy. I have no difficulties with science education; my difficulties are with science reeducation. If I can teach something about which the students have never heard, I find that they generally both welcome and understand it. It is when I have to teach them about something that they have already learned incorrectly, that I start to identify with Sisyphus.

*W*hy is science reeducation so difficult? I have identified two possible reasons, you may know of others.

- Jonathan Swift is reputed to have observed (I cannot find the original reference), "You cannot reason a person out of a position he did not reason himself into in the first place." So, if science is taught as just a collection of (assumed-to-be) facts, it is nothing but dogma. Dogma stoutly resists subsequent displacement by reason.

- It seems that anything people have learned prior to puberty takes on the status of an immutable truth (this is something well understood by parents, governments, and religions). Rational explanations of why some previous belief might be incompatible with the behavior of nature, and a careful explanation of the actual behavior of nature are of little avail.

*S*o, if science is taught as dogma to the prepubescent, just imagine the problem created for subsequent teachers. For example, most of the university students I encounter have been taught as children that the reason clouds form when air is cooled is that cold air cannot hold as much water vapor as does warm air. When I subsequently carefully explain what is really happening, and show why the previously learned nostrum is nonsense parading as science, I can usually only convince a small fraction of the students. The rest know in their hearts that their grade-eight teacher, say, or their mummy was actually right and that you are just a contrarian who is attempting to destroy the established order. The damage is done, the mind is frozen and the prepubescent dogma lasts a lifetime.

Branches to the Bad Science Pages

Bad Astronomy is brought to you by Phil Plait .

Bad Chemistry is brought to you by Kevin Lehmann and the *Princeton Section of the American Chemical Society.* The main page provides an overview and enables you to branch to:

- The Hydrophobic Effect
- Theory of Ice skating is all wet!
- Ionic solutions don't look like that!

Bad Meteorology is brought to you by Alistair B. Fraser. The main page provides an overview and enables you to branch to:

- Bad Clouds
- Bad Rain
- Bad Greenhouse
- Bad Coriolis
- Bad Meteorology FAQ

The Pathetic Fallacy is brought to you by Alistair B. Fraser.

A Class project: Search for examples of bad science (including the pathetic fallacy) in books and on the Web. Quote the bad claims, explaining what is wrong, and cite the source. This exercise has become ever so much easier these days given the power of Web search engines. In particular, it is now easy to search universities for nonsense. They are fair game, for they should know better. Search the university of your choice courtesy of a special division of google .

Be very, very careful what you put into that head,
because you will never, ever get it out.
Thomas Cardinal Wolsey (1471-1530)

Bad Clouds

Click on the symbol for its explanation.

Bad Meteorology:

The reason clouds form when air cools is because cold air cannot hold as much water vapor as warm air.

*W*hen moist air cools, a cloud can form. This much is true. The process is responsible for the cumulus cloud over Vancouver and the cap cloud over Rainier, shown to the right. Ascending air always cools. The cumulus cloud formed when air over the sun-warmed ground became buoyant and rose; the cap cloud, when the wind (coming from the right) blew against the sloping side of the mountain and was forced up.

Cumulus cloud over Vancouver, Canada

*B*ut did the clouds form because the colder air had a lower holding capacity for water vapor than the warm air? If you believe a legion of teachers (from grade school to university), TV weather broadcasters, and endless textbook writers, this is the reason. They speak of the air being saturated and one even published an illustration of the air being wrung out like a sponge as the temperature dropped (sigh...). Unfortunately, it is not true. Sure, a cloud may form as the temperature drops, but not because some mystical holding capacity of the air has decreased.

*T*o claim that a temperature-dependent holding capacity of the air caused the cloud to form in cold air is to get (approximately) the right answer for the wrong reason. It is like trying to reduce the fraction, 19/95, by imagining that you can cancel the 9s. The right answer ensues, but for the wrong reason. And, if the process was

wrong, it is unlikely to work the next time you try it in a slightly different situation.

Cap cloud over Mt. Rainier, U.S.A

*T*he air (mainly nitrogen and oxygen) no more has a holding capacity for water vapor, than, say, water vapor has for nitrogen. The atmosphere is a mixture of gases. While saturation (which involves bonds between different molecules) is a real phenomenon in liquids it does not describe the interaction of atmospheric constituents.

So, what is going on?

*W*ater molecules are constantly coursing back and forth between phases (another word for the three states: vapor, liquid, and solid). If more molecules are leaving a liquid surface than arriving, there is a net evaporation; if more arrive than leave, a net condensation. It is these relative flows of molecules which determine whether a cloud forms or evaporates, not some imaginary holding capacity that nitrogen or oxygen have for water vapor.

*T*he rate at which vapor molecules arrive at a surface of liquid (cloud drop) or solid (ice crystal) depends upon the vapor pressure.

*T*he rate at which vapor molecules leave the surface depends upon the characteristics of the surface. The number escaping varies with:

1. the phases involved --- molecules can escape from liquid more readily than from the solid (ice);
2. the shape of the boundary --- molecules escape more readily from highly curved (small) drops or ice crystals (convex);
3. the purity of the boundary --- foreign substances dissolved in the liquid or ice diminish the number of water molecules which can escape;
4. the temperature of the boundary --- at higher temperatures the molecules have more energy and can more readily escape.

*A*nd therein lies the origin of the myth. The temperature of a cloud droplet or ice crystal will be (nearly) the same as that of the air, so people imagine that somehow the air was to blame. But, if the (other gases of the) air were removed, leaving everything else the same, condensation and evaporation would proceed as before (the air was irrelevant to the behavior). To assign the behavior of water to an invented holding capacity of the air is like assigning your life's fortunes to an invented influence of the constellations (and as we all know, nobody does that anymore).

So, what do you tell your students?

*W*hat appears to be cloud-free air (virtually) always contains sub microscopic drops, but as evaporation exceeds condensation, the drops do not survive long after an initial chance clumping of molecules. As air is cooled, the evaporation rate decreases more rapidly than does the condensation rate with the result that there comes a temperature (the dew point temperature) where the evaporation is less than the condensation and a droplet can grow into a cloud drop.

*E*vaporation increases with temperature, not because the holding capacity of the air changes, but because the more energetic molecules can evaporate more readily (with, of course, the caveat that evaporation is also influenced by things other than temperature, as described above).

*I*f that explanation is not simple enough for your students, just present the facts: when the temperature drops below the dew-point temperature, there is a net condensation and a cloud forms.

*B*ut **don't** ever teach nonsense by claiming that the air has a temperature-dependent holding capacity for water vapor.

A little history

*T*he idea that it is the air which determines the amount of water vapor which can be present through some sort of holding capacity is an eighteenth century idea which was shown to be false both empirically and theoretically about two hundred years ago! The fact that it is still taught in our schools and defended by teachers and (gulp) professors, is a testimony to the mindless persistence of myth. A discussion of some of the history of this bankrupt idea is offered by Steven M. Babin .

Bad Clouds FAQ

Before writing me with a question about this page, please check the Bad Clouds FAQ to see if the issue has already been addressed satisfactorily.

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Thomas Cardinal Wolsey (1471-1530)

Bad Rain

Click on the symbol for its explanation.

Bad Meteorology:
Raindrops are shaped like teardrops.

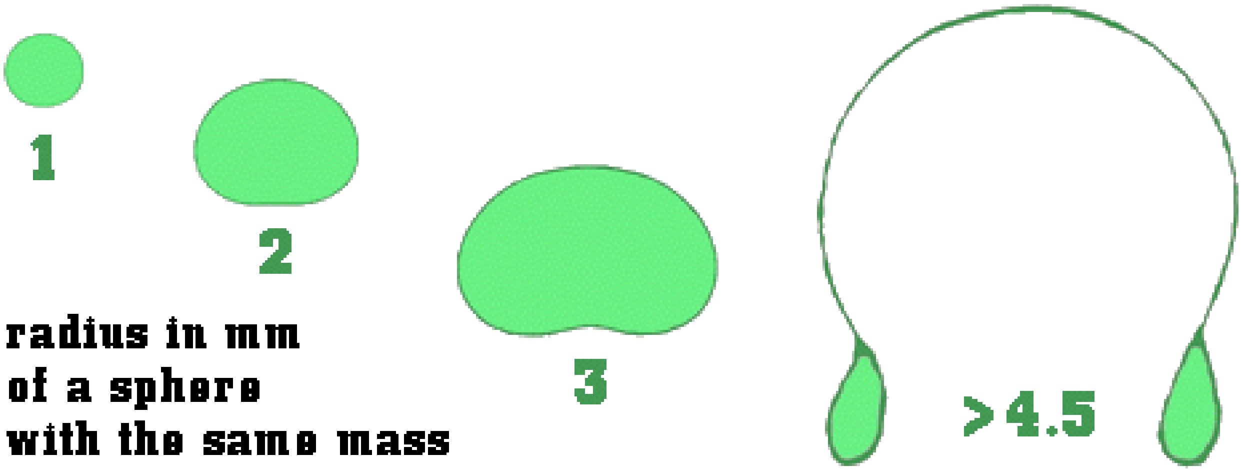
Image derived from the *Weather Channel*

*T*he artistic representation of raindrop as presented by popular culture is that of a teardrop. Actually, real raindrops bear scant resemblance to this popular fantasy (except after they have ceased to be raindrops by splattering on a window, say). It may seem too easy a target to single out the Weather Channel for criticism for their shoddy representation when virtually everyone from advertisers to illustrators of children's books do likewise. Yet, I would like to think they could be held to a higher standard as they attempt to convey the image of purveyors of accurate information.

*S*mall raindrops (radius < 1 mm) are spherical; larger ones assume a shape more like that of a hamburger bun. When they get larger than a radius of about 4.5 mm they rapidly become distorted into a shape rather like a parachute with a tube of water around the base --- and then they break up into smaller drops.

*T*his remarkable evolution results from a tug-of-war between two forces: the surface tension of the water and the pressure of the air pushing up against the bottom of the drop as it falls. When the drop is small, surface tension wins and pulls the drop into a spherical shape. With increasing size, the fall velocity increases and the pressure on the bottom increases causing the raindrop to flatten and even develop a depression. Finally, when the radius exceeds about 4 mm or so, the depression grows almost explosively to form a bag with an annular ring of water and then it breaks up into smaller drops. See, for example Pruppacher and Klett, Microphysics of Clouds and Precipitation, (1978, Reidel, Boston), pp. 316-19, or any other book on cloud physics written by competent authors.

*T*he way raindrops change in shape as they grow is sketched in the cross-sections of drops below. As the drops become distorted, the meaning of a radius becomes vague, so the radius labeled is that of sphere which has the same mass.



These are cross-sections through the drop. Imagine spinning the drop through a vertical axis to see the real shape. So, what looks like some teardrops in the final illustration on the right is actually closer to being a tube of liquid just before it breaks up into small spherical droplets again.

Bad Rain FAQ

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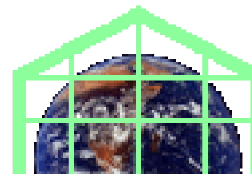
Bad Greenhouse

Click on the symbol for its explanation.

Bad Meteorology:
The greenhouse effect is caused when
gases in the atmosphere behave as a blanket
and trap radiation which is then reradiated to the Earth.



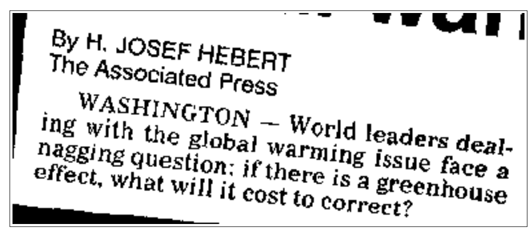
First,

Let's get one thing straight.

The greenhouse effect and global warming ARE NOT the same thing.

There is a *greenhouse effect*, but, if there were not, we would all be dead!

It is becoming increasingly clear that we are also experencing *global warming*, but, that is a different matter.



By H. JOSEF HEBERT
The Associated Press
WASHINGTON — World leaders dealing with the global warming issue face a nagging question: if there is a greenhouse effect, what will it cost to correct?

Silly copy

The *greenhouse effect* is the name applied to the process which causes the surface of the Earth to be warmer than it would have been in the absence of an atmosphere. (Unfortunately, the name, greenhouse effect is a misnomer --- more on that later.)

Global warming is the name given to an expected increase in the magnitude of the greenhouse effect, whereby the surface of the Earth will amost inevitably become hotter than it is now.

This page *only* treats the greenhouse effect --- not global warming.

Second,

Let's establish why there is a greenhouse effect.

> *The surface of the Earth is warmer than it would be in the absence of an atmosphere because it receives energy from two sources: the Sun and the atmosphere.*

*T*he atmosphere emits radiation for the same reason the Sun does: *each has a finite temperature.* So, just as one would be warmer by sitting beside two fireplaces than one would have been if one fireplace were extinguished, so, one is warmer by receiving radiation from both the Sun and the atmosphere than one would be if there were no atmosphere.

*C*uriously, the surface of the Earth receives nearly twice as much energy from the atmosphere as it does from the Sun. Even though the Sun is much hotter, it does not cover nearly as much of the sky as does the atmosphere. A great deal of radiation coming from the direction of the Sun does not add up to as much energy as does the smaller portion of radiation emitted by each portion of the atmosphere but now coming from the whole sky. (It would take about 90,000 Suns to paper over the whole sky).

*S*o, it isn't even as if our atmosphere had only a minor influence on the surface temperature; it has a profound one. In the absence of an atmosphere the Earth would average about 30 Celsius degrees (about 50 Fahrenheit degrees) lower than it does at present. Life (as we now know it) could not exist.

Third,

Let's examine some of the nonsense frequently offered in the name of science.

- Is the greenhouse effect a good thing?

  Well, yes, if you appreciate living.

- Does the atmosphere (or any greenhouse gas) act a blanket?

  At best, the reference to a blanket is a bad metaphor. Blankets act primarily to suppress convection; the atmosphere acts to enable convection. To claim that the atmosphere acts a blanket, is to admit that you don't know how either one of them operates.

- Does the atmosphere trap radiation?

  No, the atmosphere absorbs radiation emitted by the Earth. But, upon being absorbed, the radiation has ceased to exist by having been transformed into the kinetic and potential energy of the molecules. The atmosphere cannot be said to have succeeded in trapping something that has ceased to exist.

- Does the atmosphere reradiate?

  One often hears the claim that the atmosphere absorbs radiation emitted by the Earth (correct) and then reradiates it back to Earth (false). The atmosphere radiates because it has a finite temperature, not because it received radiation. When the atmosphere emits radiation, it is not the same radiation (which ceased to exist upon being absorbed) as it received. The radiation absorbed and that emitted do not even have the same spectrum and certainly are not made up of the same photons. The term reradiate is a nonsense term which should never be used to explain anything.

  Sometimes diagrams are drawn which show the radiation from the Earth's surface rising into the sky and being reflected off of the atmosphere (or clouds, or greenhouse gasses). This too is nonsense. The radiation was not reflected, it was absorbed and different radiation was subsequently emitted.

- Does the atmosphere trap heat (in producing the greenhouse effect)?

  Alas no. As rapidly as the atmosphere absorbs energy it loses it. Nothing is trapped. If energy were being trapped, i.e. retained, then the temperature would of necessity be steadily rising. Rather, on average, the temperature is constant and the energy courses through the system without being trapped within it.

- Does the atmosphere behave like a greenhouse?

  The name, greenhouse effect is unfortunate, for a real greenhouse does not behave as the atmosphere does. The primary mechanism keeping the air warm in a real greenhouse is the suppression of convection (the exchange of air between the inside and outside). Thus, a real greenhouse does act like a blanket to prevent bubbles of warm air from being carried away from the surface. As we have seen, this is not how the atmosphere keeps the Earth's surface warm. Indeed, the atmosphere facilitates rather than suppresses convection.

  One sometimes hears the comparison between the greenhouse effect in the atmosphere (not in real greenhouses) and the interior of a parked car which has been left in the summer Sun with its windows rolled up. This comparison is as phony as is the comparison to real greenhouses. Again, keeping the windows closed merely suppresses convection.

Whether the topic is a real greenhouse or a car, one still hears the old saw that each stays warm because visible radiation (light) can pass through the windows, and infrared radiation cannot. Actually, it has been known for the better part of a century that this has very little bearing on the issue.

Finally,

What does one tell one's students?

The correct explanation (as offered above) is remarkably simple and easy to understand, namely:

The surface of the Earth is warmer than it would be in the absence of an atmosphere because it receives energy from two sources: the Sun and the atmosphere.

But *don't* ever teach nonsense by claiming that the radiation is trapped, or that the atmosphere reradiates, or that the atmosphere behaves as a greenhouse (or parked car), or that greenhouse gasses behave as a blanket.

Bad Greenhouse FAQ

Before writing me with a question about this page, please check the Bad Greenhouse FAQ to see if the issue has already been addressed satisfactorily.

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Thomas Cardinal Wolsey (1471-1530)

Bad Coriolis

Click on the symbol for its explanation.

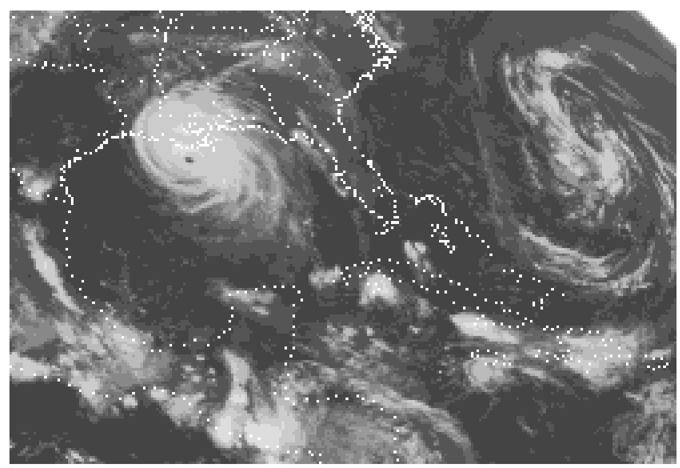
Bad Meteorology:

The water in a sink (or toilet) rotates one way as it drains in the northern hemisphere and the other way in the southern hemisphere. Called the Coriolis Effect, it is caused by the rotation of the Earth.

*F*irst on this page is a discussion of the issue. Towards the bottom of the page you can see examples of incompetence from *PBS*,*NPR*, and *Sports Illustrated*.

The Coriolis force does influence long-lasting vortices.

*O*n the scale of hurricanes and large mid-latitude storms, the Coriolis force causes the air to rotate around a low pressure center in a cyclonic direction. Indeed, the term cyclonic not only means that the fluid (air or water) rotates in the same direction as the underlying Earth, but also that the rotation of the fluid is due to the rotation of the Earth. Thus, the air flowing around a hurricane spins counter-clockwise in the northern hemisphere, and clockwise in the southern hemisphere (as does the Earth, itself). In both hemispheres, this rotation is deemed cyclonic. If the Earth did not rotate, the air would flow directly in towards the low pressure center, but on a spinning Earth, the Coriolis force causes that air to be deviated with the result that it travels around the low pressure center.



Hurricane Andrew

*I*n the accompanying picture of the Caribbean, one can see the cyclonically spiraling clouds of Hurricane Andrew (at the mouth of the Mississippi) and of another vortex in the Atlantic.

But, the Coriolis force is very small, indeed.

water draining in the supposedly wrong way

*C*ompared to the rotations that one usually sees (tires on a travelling automobile, a compact disc playing music, or a draining sink), the rotation of the Earth is very small: only one rotation per day. The water in a sink might make a rotation in a few seconds and so have a rotation rate ten thousand times higher than that of the Earth. It should not be surprising, therefore, to learn that the Coriolis force is orders of magnitude smaller than any of the forces involved in these everyday spinning things. The Coriolis force is so small, that it plays no role in determining the direction of rotation of a draining sink anymore than it does the direction of a spinning CD.

*T*he direction of rotation of a draining sink is determined by the way it was filled, or by vortices introduced while washing. The magnitude of these rotations may be small, but they are nevertheless gargantuan by comparison to the rotation of the Earth. I decided to include a picture of a draining sink, and the first one I tried in my house was found to drain clockwise (the opposite of what the silly assertions would have it do here in the northern hemisphere). This direction was determined entirely by the way the tap filled the sink. The direction of rotation of a draining toilet is determined by the way the water just under the rim is squirted into the bowl when it is flushed.

Is it possible to detect the Earth's rotation in a draining sink?

*Y*es, but it is very difficult. Because the Coriolis force is so small, one must go to extraordinary lengths to detect it. But, it has been done. You cannot use an ordinary sink for it lacks the requisite circular symmetry: its oval shape and off-center drain render any results suspect. Those who have succeeded used a smooth pan of about one meter in diameter with a very small hole in the center. A stopper (which could be removed from below so as to not introduce any spurious motion) blocked the hole while the pan was being filled with water. The water was then allowed to sit undisturbed for perhaps a week to let all of the motion die out which was introduced during filling. Then, the stopper was removed (from below). Because the hole was very small, the pan drained slowly indeed. This was necessary, because it takes hours before the tiny Coriolis force could develop sufficient deviation in the draining water for it to produce a circular flow. With these procedures, it was found that the rotation was always cyclonic.

Why do teachers claim that a draining sink reflects the rotation of the Earth?

A surprisingly large number of my undergraduate students tell me that their high-school teachers told them that sinks drain in opposite directions in the two hemispheres owing to the rotation of the Earth. Why would a teacher offer such garbage to students when it is so easy to check. A trip to the school washroom (let alone the ones at home) will reveal drainage in both directions (which would certainly require the equator to assume a tortuous track through the countryside).

*I*s knowledge just a bunch of abstractions to be memorized with no recourse to the relevance of everyday experience?

*S*igh... I don't know why teachers do this. I can but assume that those who do so just never feel any need to wash their hands --- or their minds.

Incompetence from those we trust

Incompetence from PBS (USA)

Fakery of the first water (so to speak).
*T*here are charlatans operating at a tourist trap in Nanyuki, Kenya. In this little town, located right on the equator, a local mountebank works for tips as he glibly cons busloads of tourists into believing that the rotation of the Earth causes water draining from a container to spin clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere. (Yes, you read that correctly, the charlatan fakes it backwards. You would think that if he were going to sucker people, he would at least get his directions the same as what really happens in large weather systems.)

*T*his man's nonsense was captured (and endorsed) by Michael Palin in one episode of his BBC TV special, *From Pole to Pole,* which is often aired on PBS. The presentation went as follows:

faker:

> This is the northern hemisphere (gesturing to his left), and this is the southern hemisphere (gesturing to his right). If you drain a sink when you're on the northern side of the equator, and you watch the water as it drains, you will see that the water always rotates

clockwise [sic]. (Shot of a pan with water draining clockwise. Floating match sticks are used to make the motion easier to see.) This phenomenon is caused by the rotation of the Earth. The effect becomes stronger according to how far you move to the north or to the south and becomes weaker according to how close you go towards the line [the equator]. So that's why we have to give some distance from the equator so that the rotation can be noticeable.

Palin:

This is known as the Coriolis effect and Peter McLeary has given this same lecture every day for the last six years. It's delivered in the burnt out shell of an old hotel. The equator used to run through the middle of the bar. I bet they were always floating match sticks in the middle of the beer. (The faker has been carrying his pan and water about ten meters to the south of the spot marking the equator, and turns to face the audience.)

faker:

So, this changes to counter-clockwise [sic] indicating that now we are on [sic] the southern hemisphere. (Shot of the water in the pan draining counter-clockwise.)

(Transition to a scene where the faker is placing the water-filled pan directly on the equatorial marker.) So, now we are right on the equator, and as we drain the water, you'll see there will be no rotation. It just drains straight down. And that's how we prove that we are right on the equator. (Water draining with no apparent rotation.)

Palin:

It does work.

*S*ure it does --- in the hands of a mountebank, that is. And now we have Michael Palin acting as a shill for bad science --- and on PBS, no less.

*B*ut, how is the fraud accomplished? The Coriolis force is so tiny that it cannot cause the rotation in the faker's draining pan; indeed at only ten meters to either side of the equator, it is so tiny that it could influence neither the carefully performed experiment (described above) nor the large scale motions of weather systems.

*S*o, the faker must be forcing the rotation by other means, and by a sufficiently unobtrusive way that the busloads of tourists do not spot the means. Indeed, a colleague of mine, who witnessed the performance first hand and knew it was a cheat, was not able to spot how the fraud was perpetrated. (It is an interesting sidelight that when back on the bus, he informed his fellow tourists that they had just witnessed fakery --- the Earth did not cause the rotation they had just seen --- there was widespread disappointment. The tourists preferred the fantasy to the reality.)

Huh?
A correspondent has written me to say that in the version of the program she saw, that "Mr. Palin proceeded to describe how the demonstration was pure bunk and told how the charlatan pulled off his little deception..." Yet, in my version of the program, Palin unambiguously endorses the demonstration.

Could it be that there are two versions out there, the original and an amended one in which Palin attempts to address some of the criticism of the original? Does anyone know?

So far, the only readers who have written me on this point are ones who have seen the Palin-endorsing version. There are no further reports of a version where Palin is claimed to have pointed out that the demonstrator had cheated.

Do-it-yourself fakery.

*T*here are two clues to the successful fakery of the drainage changing direction at the whim of the mountebank. One is revealed in each of the two images (above) which I captured from the TV program:

Non-circular pan

The non-circular pan allows the faker to easily introduce rotation into the pan after he begins. Let us imagine that the pan is filled very carefully so that there is no rotation initially. Indeed, one wants to be able to show the audience that any rotation introduced while filling has died out. Now what? If the pan were circular, it would be harder to start the water spinning by turning the pan itself, but by having the pan nearly square, the water must turn if the pan does.

Turn to face the audience

But how does one turn the pan without the audience becoming suspicious. Obviously, it must be done in such a way that the audience does not attribute the action to part of the fakery, but to a courtesy which enables them to see better.

The procedure is as follows:

- *Find the materials*

  You want two plastic containers: one which is to be the pan to be drained, and the other is a bucket for the storage of water. The pan should be non-circular. I found a quasi-square one (made by Sterilite) for $1.28 in the local Wal-Mart. It is the three-cup size (.7 liter). It works well. Drill a hole (say, 1/4 inch or 3/8 inch) through the center bottom. You don't need a special stopper for the hole: your finger placed underneath works just fine. The other container can be any small plastic bucket with the only restriction that your pan should be able to sit on top of it so that the bucket can catch the water as it drains.

- *Fill the pan*

  Choose the spot that you wish to claim is the equator (the center of your classroom will do). Fill the pan from the bucket there and let the motion from filling die out. (You can insert and then gently remove a vertical object, such as index card, into the water to dampen the motion.) You can then show that there is little or no circulation by floating a match stick (or sprinkling pepper) on the water.

- *Covertly add the chosen rotation*

  If you are going to the north side of the equator, stand in front of the pan facing south. Pick it up, *turn around by turning to your left*, walk to the north end of the room, *turn around by turning to your left*, and face the audience. As you have a non-circular pan, you have now introduced counter-clockwise rotation (which is cyclonic in the northern hemisphere) into the water.

- *The coup-de-grace*

  Add a tracer (such as matches or pepper). Remove the stopper (your finger) and let the water drain. Lie through your teeth by claiming that it is the rotation of the Earth here in the north which is causing the water to circulate the way it does.

- *The other hemisphere*

  Go back to the equator but this time stand on the south side looking north. After filling the pan, *turn around by turning to your right*, walk south, again *turn around by turning to your right* to face your audience (cyclonic rotation in the southern hemisphere is clockwise), and remember to complete the demonstration by lying again.

- *The equator*

  This is the hardest part of the fakery, because it is actually very difficult indeed to eliminate all rotation from a pan of water. It really should sit for a very long time (and your finger might get tired). If the pan is fairly deep, and the hole small, it takes a moment or two before the rotation is apparent. This seems to be the dodge followed by the Kenyan faker.

*W*hat can I say, it all worked the very first time I tried it. If any of you can devise any improvements in the procedure, please send me a note.

Incompetence from Sports Illustrated

One does not normally turn to *Sports Illustrated* for insight into the natural world, unless, possibly that bit of the natural world which sometimes wears swimming suits. However, one does not expect incompetence from the magazine either. Yet, the special Winter 1998 swimsuit issue offers much more than its standard set of salacious images, it offers geographic and scientific swill. In an article by Jamie Malanowski, entitled, Zero Latitude, (starting on page 16) we learn:

> Say you're vacationing at a nice hotel in Costa Rica [sic]. Feeling restless, you go for a walk, heading in a generally southern direction. After a few days and a few beverages of your choice, you stop at an appropriate facility and do what you do whenever nature calls. When you flush, you note that the water whirls down the bowl in a counterclockwise direction. Now resume your walk. Go far enough south, and the next time you hit the head, the water will spin clockwise down the drain. And then it hits you: Somewhere back there you crossed the equator!

Apart from the fact that the equator is one very long (and difficult) walk from Costa Rica, any difference in the behavior of toilets on the journey is the result of happenstance and not the crossing of the line.

Incompetence from NPR (USA)

*O*n October 16, 1996 the NPR program, *Rewind*, blotted its escutcheon with their nonsensical discussion of the Coriolis force. The librarian who prepared it supported her position with references to the book, *Rainbows, Curveballs and other Wonders of the Natural World Explained*, by Ira Flatow, host of NPR's Talk of the Nation - Science Friday and with a previously aired PBS (cum BBC) program called, Pole to Pole (or, Full Circle). You can read about the silliness in Pole to Pole, above. I have yet to see just what it is that Flatow had to say. *Note*: The program has since retracted its mistake.

Incompetence from the author of a standard undergraduate physics textbook.

A physics student from Nottingham University, in the U.K., wrote to tell me that the physics textbook they are assigned in one of his courses states:

> "...on a smaller scale, the coriolis effect causes water draining out a bathtub to rotate counter clockwise in the northern hemisphere..."

Sigh, this mind-numbing example of scientific incompetence is offered by author, Paul A. Tipler, on page 128 of his book, *Physics for Engineers and Scientists*, 4th Edition. One wonders if Tipler gets the relative magnitude of the other forces in nature wrong, or if he reserves this privilege for the Coriolis force. In the U.S.A., the book's publisher is W.H.Freeman, and in the U.K. it is Worth Publishers. *SHAME ON BOTH PUBLISHERS.*

But, competence from teachers

So what do you tell your students.

*T*he direction of rotation in draining sinks and toilets is *NOT* determined by the rotation of the Earth, but by rotation that was introduced earlier when it was being filled or subsequently being disturbed (say by washing). The rotation of the Earth does influence the direction of rotation of large weather systems and large vortices in the oceans, for these are very long-lived phenomena and so allow the very weak Coriolis force to produce a significant effect, with time.

Bad Coriolis FAQ

*B*efore writing me with a question about this page, please check the

Bad Coriolis FAQ to see if the issue has already been addressed satisfactorily.

Be very, very careful what you put into that head,
because you will never, ever get it out.
Thomas Cardinal Wolsey (1471-1530)

Bad Meteorology FAQ

Click on the symbol for its explanation.

Preamble

*T*his FAQ (Frequently Asked Questions) is written by Alistair B. Fraser. It is in response to questions posed over the years by readers of the Bad Meteorology pages. If you have arived on this page without having read those pages or the other Bad Science pages, then what follows, will probably make little sense.

Although the questions presented here are often ones asked by a specific person, each is chosen to characterize a group of similar questions which have been asked about the topic.

Questions grouped by topics

Bad Clouds FAQ (arising out of the Bad Clouds page)

- Air is a sponge
- But, air does have a holding capacity for water vapor
- A correct prediction implies a correct reasoning
- The air-holding water explanation is just a simplification

Bad Rain FAQ (arising out of the Bad Rain page)

- Terminal velocities
- Artistic representation

Bad Greenhouse FAQ (arising out of the Bad Greenhouse page)

- Temperature conversion
- Our atmosphere is not the source of the energy
- But the Sun and atmosphere emit for different reasons
- But our atmosphere would stop emitting without the Sun

- Is it the same radiation emited as received?

Bad Coriolis FAQ (arising out of the Bad Coriolis page)

- You have it backwards
- Why any spin at all?
- Its not the Coriolis force, but the Coriolis effect
- The Coriolis force is fictitious, because it cannot do work
- The teacher was right
- On firing missiles
- Temporal scale versus spatial scale
- Wacky things attributed to Coriolis

General meteorological FAQ

- The full moon and frost
- Heat lightning

Teaching FAQ

- Employment of metaphors
- Persistence of textbook errors
- Teacher intransigence

Be very, very careful what you put into that head,
because you will never, ever get it out.
Thomas Cardinal Wolsey (1471-1530)

Badness Survey

Click on the symbol for its explanation.

Proffering Garbage as Gems

*M*any educators are concerned with making sure that students are presented with a shopping list of knowledge and information. Curricular committees assemble and compile irreducible lists of topics to which a student should be exposed before graduation. (We would not want any of our graduates to have to express ignorance on topic x, so we had better add topic x to our already long list of topics to teach).

*D*uring the process of provisioning students with a vast storehouse of knowledge, it would appear that little attention is directed towards eliminating misinformation. The survey presented below, albeit anecdotal and in only one field, would suggest that the probability of having students being offered garbage as if gems is amazingly high in all levels of our educational system.

*S*urely the elimination of proffered misinformation should be as important a concern for educators (and curricular committees) as the provisioning of proffered information. Yet the results of the survey presented below seem to suggest that the former does not play much of a role in the considerations of educators.

The results of a class survey

*I*n November 1996, I handed the members of my sophomore class of beginning meteorology students a questionnaire about the extent to which they had been taught scientific nonsense and from whom they might have learned it. I received 44 total responses. The percentages can add up to more than 100% because, some people learned the same thing from a number of different sources.

Percentage of Penn State University sophomores in meteorology who had acquired bad information from a particular source (sample size = 44 students)

garbage proffered as gems	*not at all*	*home*	*text-books*	*maga-zines/TV*	*grade school*	*high school*	*univer-sity*

Clouds form because cold air cannot hold as much water vapor as warm air.	39%	7%	27%	30%	32%	30%	5%
There are 7 colors in the rainbow.	5%	32%	32%	36%	86%	34%	7%
The atmosphere behaves like a greenhouse.	9%	5%	41%	50%	41%	64%	14%
Greenhouse gases behave like a blanket.	18%	5%	32%	41%	27%	61%	11%
Direction of rotation in sink is determined by Earth's rotation.	2%	14%	7%	39%	16%	41%	2%
Raindrops are shaped like teardrops.	6%	14%	16%	64%	50%	16%	9%
Average	*13%*	*13%*	*26%*	*43%*	*42%*	*41%*	*8%*

Comments

*F*or any particular piece of misinformation, nearly 90% of the students are likely to have been taught it (100% - 13% = 87%). That is an amazingly high probability of acquiring any particular one of the six pieces of nonsense and represents a virtual certainty that a student will be exposed to at least one of them.

Interpretation of these numbers is fraught with problems. Even taking the average as I have, assumes an unjustified equal weighting of the topics. But the numbers here are only viewed as a hint at the issues.

- *Home*

  At first it might seem that the relatively low probability of getting any particular piece of scientific misinformation in the home implies a greater concern for the truth there. Of course, the more reasonable interpretation is that less scientific *misinformation* is offered in the home because less scientific *information* is offered there. During the next class, I asked my students whether this was, in fact, the proper interpretation and they roundly asserted that yes, it was.

- *Textbooks versus magazines and TV*

Despite the better (but not good) showing of textbooks by comparison to magazines and television, I suspect that this merely suggests that students actually acquire more information (and thus more misinformation) via the latter two than via textbooks. Certainly, my own reading of textbooks suggests that they are a rich mine of nonsense.

- *Educational institutions*

  The probability of acquiring any particular piece of nonsense from an educational institution is about the same as that for magazines or television. This is a shameful indictment of our educational system! At first it might be thought that the universities do a better job than the grade schools or high schools. but each of the latter represents an exposure of about six years while the students surveyed had in generally only been at the university for a year and a few months. If one scaled the data to give the probability of acquiring a particular piece of misinformation per unit time, it is clear that the universities don't do any better than the public schools: all do an abysmal job.

More to be feared than ignorance is the illusion of knowledge.

Lightning Injury Research Program

Lightning Injury Research Program

Mary Ann Cooper, MD

University of Illinois at Chicago

[Overview of Lightning Injury]

[Lightning Facts]

[Acute Treatment]

[Lightning Injury Distribution]

[Psychological Impact]

[Safety Guidelines]

[Publications and Presentations]

[LI Support Group]

[Related Links]

[Upcoming Events]

[Our Partners]

[Lightning Safety Week]

[Contact Us]

Lightning Safety Awareness Week 2004 June 20-26
National Weather Service's Lightning Safety Website

http://www.lightningsafety.noaa.gov/

Our GOALS in preparing this website are to provide:

- **An informational and educational tool for survivors of lightning strike and the physicians who treat them.**
- **A safety resource for those responsible for organizing outdoor activities including parents, coaches, teachers, camp counselors, park managers, and others engaged in outdoor activities.**
- **An educational resource for students, teachers, and the media.**

Click on the link at the left to go to the area that interests you.

What this site does NOT do:

- **give specific medical advice to any individual**
- **give advice on protection of buildings or structures**

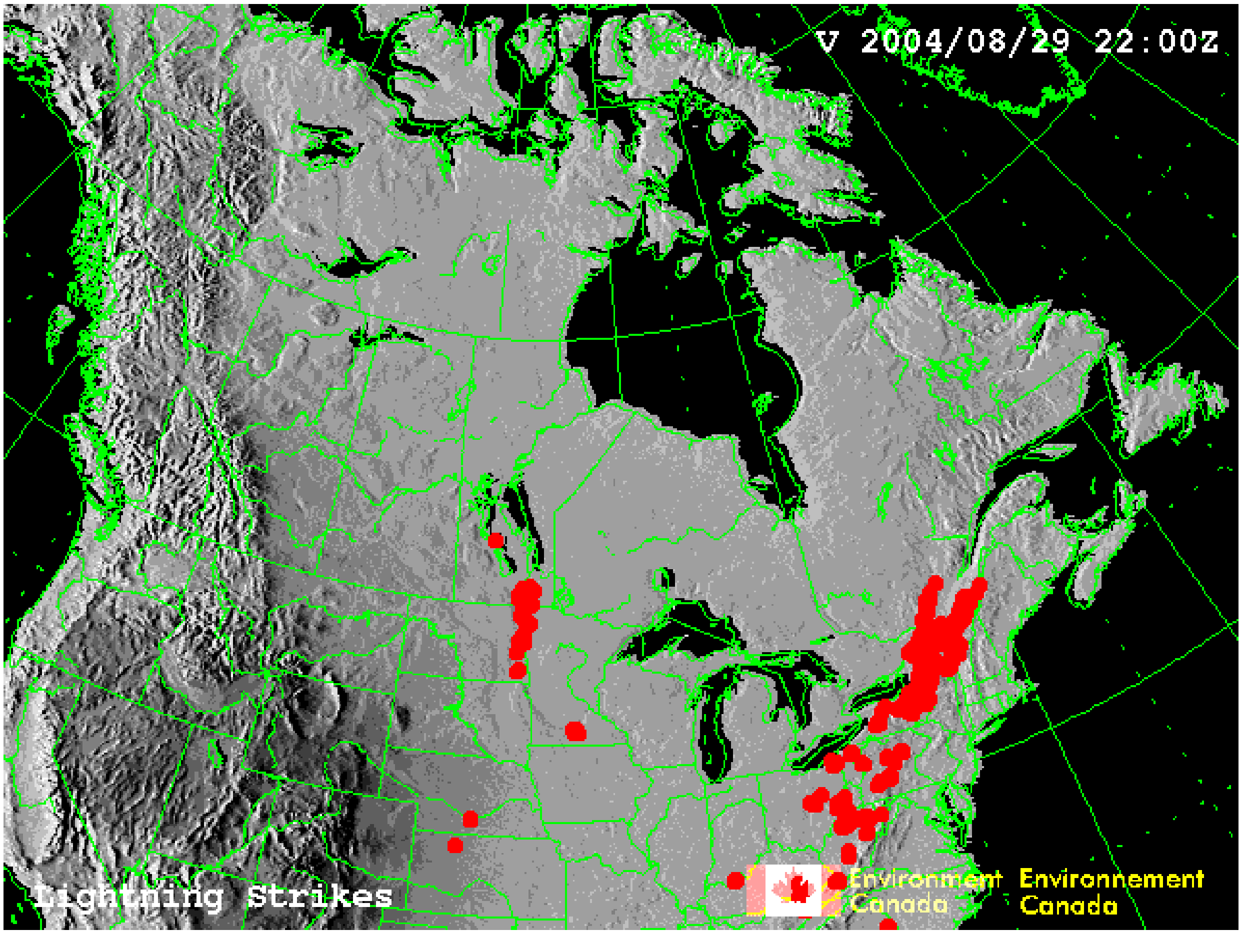
DISCLAIMER - General statements made in this site should not be taken as recommendations for a specific course of treatment for any individual. Specific medical advice should be obtained through consultation with a physician or other trained health care professional.

This web page was last updated on Sept 12, 2003. Please click reload on your browser to get the latest updates!

Lightning Hot Spots, safety tips and general information - a series of maps showing where lightning occurs most frequently in Canada, lightning activity in major cities, safety tips and more information.

Lightning Activity

This lightning flash product displays only a portion of the lightning activity in any given hour. It consists of cloud to ground flashes observed during a 10 minute interval ending at the time shown on the image (upper right hand corner). Data are updated hourly, with a 2 hour delay.



Environment Canada offers access to real-time commercial lightning strike information on a subscription or pay-per-use basis. For further information, please email us through this site, or use the following contact numbers:

National:	(604) 664-9080
BC and Yukon:	(604) 664-9080
Alberta, Manitoba, Saskatchewan,Nunavut & Northwest Territories:	(403) 299-7804
Ontario:	(416) 739-4578
Québec:	(514) 283-1104
Atlantic Canada:	(902) 426-4926

The Canadian Lightning Detection Network

The Canadian lightning detection network increases public safety by allowing meteorologists to detect and monitor thunderstorms at an early stage in their development.

Thunderstorms are always accompanied by lightning and may produce damaging and dangerous weather such as tornadoes, hail, high winds and heavy rain. Using information from the lightning detection network and other data such as doppler radar, meteorologists will be able to detect thunderstorms earlier, track them more accurately, and if necessary, issue severe weather warnings sooner -- in some cases, one to three hours before a storm hits.

Early warnings give Canadians more time to take appropriate steps to protect themselves, such as:

- cancelling outdoor recreational activities, like baseball and soccer games;
- getting out of the water or sailing to shore before a storm strikes;
- taking shelter if working outdoors on construction sites or farmers' fields.

In Canada, lightning kills about seven people and seriously injures 60 to 70 people a year. Among the 9,763 fires recorded by the Canadian Forestry Service in 1994, 5,324 resulted directly from lightning. The geographic area burned by fire rose to 6,292,021 hectares. The average annual cost of forest fires between 1979 and 1993 is 14 billion dollars.

Severe weather such as thunderstorms, lightning, tornadoes, hail, heavy rains and high winds also exact a high toll. In the 1980s, tornadoes in Barrie and Edmonton killed 35 people. Hail storms in Calgary and Winnipeg in the summer of 1996 resulted in property losses of close to $300 million. In August of the same year, heavy rains hit the Ottawa/Hull area, resulting in total insured property damage of more than $20 million. That figure does not include the cost of repairing the sewers and roads.

[Graphics off] | [Format for print] |

Created : 2002-12-31

Modified : 2002-12-31

Reviewed : 2002-12-31

Url of this page : http://www.weatheroffice.ec.gc.ca/lightning/index_e.html

Lightning Hot Spots in Canada

Welcome
Map of Canada's "Hot Spots"
Detailed maps of "hot" provinces
Lightning activity in major cities in Canada
About the lightning detection network
See Lightning across Canada as it happens
Lightning Safety Tips
For media
For Students and Teachers: Lightning Safety Poster
More information: Severe Storms
Links
Other Educational Sites

Welcome

Lightning flashes occur in Canada about 2.7 million times a year, including about once every three seconds during the summer months. This is based on observations collected during the past five years from the Canadian lightning detection network. Lightning can be deadly. A lightning bolt can carry up to 100 million volts of electricity - a million times more powerful than household current. Each year in Canada, lightning strikes kill about half a dozen people, seriously injure about 70 others, and ignite some 4,000 forest fires. In a recent study, Environment Canada scientists identified several lightning hot spots across the country. See how often lightning strikes in your local area, check out our lightning safety tips and tune into our cross-Canada lightning detection network to see lightning as it happens.

- Map of Canada's "Hot Spots"
- Detailed maps of "hot" provinces: Ontario, Saskatchewan, Alberta, Manitoba and Atlantic Canada
- Lightning activity in major cities in Canada
- About the lightning detection network
- See Lightning across Canada as it happens
- Lightning Safety Tips
- For Media
- For Students and Teachers
- More Information: Severe Storms
- Links

Created : 2003-07-24
Modified : 2003-07-28

Reviewed : 2003-07-28

Url of this page : http://www.msc.ec.gc.ca
/education/lightning/index_e.html

Canada

The Green Lane^{TM},
Environment Canada's World Wide Web Site.

Lightning and Shock Menu

This is a webforum to discuss and comment on Lightning and Shock.

Click here to Enter a new Neurology WebForum article...

Click Here to Read our Forum Disclaimer and Statement of Purpose

This Web Forum is not moderated in any sense. Anyone on the Internet can post articles or reply to previously posted articles, and they may do so anonymously. Therefore, the opinions and statements made in all articles and replies do not represent the official opinions of MGH and MGH Neurology. Neither is MGH or MGH Neurology responsible for the content of any articles or replies. No messages are screened for content.

01/01/2000 - Very Important Message! - Please Click Here to Read

Current Posts: April 7, 1998 to Present

Useful Websites can be found and posted here!

- New MGH Neurology Webforum! (12/30/99) 7:25 PM
- forum working OK now (12/27/99) 1:10 PM
- My Girlfriend Farts on Cake at restauran (12/10/99) 2:44 PM
- God centered post- prayer for all (12/7/99) 12:18 AM
- Everything is possible!!!!! (12/3/99) 11:21 PM
- 11 KV Electrical Shock. (11/29/99) 10:02 AM
- Shock therapy (11/13/99) 7:22 PM
- Could I get killed?? (11/10/99) 9:14 PM
- MINNIE and MICKEY get a divorce (11/3/99) 8:01 AM
- All You Want!!! (11/1/99) 3:34 AM
- Electrical Shock, will pain go away??? (10/31/99) 10:58 PM
- ELECTROCUTION-SEIZURES (10/25/99) 11:02 PM

IMPORTANT: If this page seems to be missing recently added documents, click the "Reload Page" button on your Web Browser to update the menu.

Return to the main Neurology WebForum Page.

These forums are maintained by the Department of Neurology at Massachusetts General Hospital
John Lester - Webspinner

www.BrainChat.org

Neurology Chatrooms at Massachusetts General Hospital

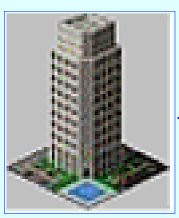
*These Chat Rooms are provided as a **free public service since 1995** by the Department of Neurology at Massachusetts General Hospital. They were created and are managed by John Lester, and are part of the BrainTalk Communities.*

Note: By entering our chatrooms, you are agreeing to our Terms of Service.

This site does not constitute an attempt to practice medicine. Use of the site does not establish a doctor-patient relationship, and individuals should consult a qualified health care provider for medical advice and answers to personal questions.

IF YOU HAVE A SERIOUS MEDICAL/NEUROLOGICAL PROBLEM, CONSULT A PHYSICIAN IN PERSON FOR PROPER CARE!

We currently offer **3 different chatroom environments**, each of which is unique and special.
Please try them all and pick your favorite! Just click on one to learn more about it.


Advanced Chatrooms


Classic Chatrooms

Palace "Virtual Reality"

Chatrooms

Advanced Chatrooms

The Advanced Chatrooms offer a wide range of advanced features. You can connect in a variety of ways, using **Java** or **HTML** (for WebTV users) or any **standard IRC client**:

Here is a list of the features of the Advanced Chatrooms:

- Nickname registration (allows you to "reserve" your nickname).
- User profiles (information you can share with other users if you wish)
- Fast and automatic updating of messages.
- The ability to exchange files between users.
- The ability to send "memos" to other users, even if they are not currently online.
- Multimedia (expressive sounds and graphics)
- **Full IRC client compatibility**
- You can use any IRC client (such as mIRC)
    - **First, you must register a username and password** by going through the registration process on this page. Once you are emailed your username and password, THEN you can connect via IRC.
    - The IRC **server address** is **132.183.185.106** and the **port number** is **7000**

If you have technical problems running the Advanced Chatrooms, you can get technical help directly from ChatSpace (the company that makes the software). You can also directly give the company useful feedback on bugs and other problems. Please visit this support page, and **be sure to tell them** that the server is running **"ChatSpace Community Server 2.1 build 76."**

Click here to go directly to the Advanced Chatrooms.

[Return to Top]

Classic Chatrooms

These chatrooms are web-based and **do not require any Java**. They are very basic and easy to use, do not require registration, and should work very well with browsers like Lynx or WebTV. I call them "Classic" because they are very similar to the original chatrooms we began using in 1995...but better! One special feature of the Classic Chatrooms is that they allow people to express themselves using **special graphics** along with text. You can be very creative with them.

Click here to go directly to the Classic Chatrooms Homepage.

[Return to Top]

Palace "Virtual Reality" Chatrooms

The Palace "Virtual Reality" Chatrooms are a special place. They are **completely** graphical, you can create avatars (a customized graphical representation of yourself), and you can explore rooms that actually look like **real rooms**!

Click here to go directly to the Palace "Virtual Reality" Chatrooms Homepage.

[Return to Top]

If you want to organize chat times with friends, need general assistance, or would like to give feedback on any of these chatrooms, please visit the Chatroom Feedback Forum.

If you'd like to participate in a **bulletin-board-type discussion** (where your posts are **permanently** stored on the server),
please visit our BrainTalk Communities at www.BrainTalk.org

[Neurology Department at Massachusetts General Hospital]

Welcome to our Lightning_and_Electric_Shock Chatroom

Occupants: The chatroom is currently empty.

Log on Instructions	• **Nickname**: Type the name that you want to go by in the chat room. • **Text Color**: Choose a color for your messages. The default is black. • **[Join Chat]**: Just click this button to enter the chat room! • **Remember Settings:** Check this to set a cookie which stores your **Nickname** and **Text Color** for future logons.

Inappropriate behavior will NOT be tolerated on this system.

The content of ALL PRIVATE MESSAGES are LOGGED and SAVED on this server, along with the user's IP address and exact date and time of transmission.

These private message logs are ONLY accessible by the System Administrator, and are periodically reviewed for inappropriate content.

Any user sending inappropriate private messages will be immediately banned and reported to their Internet Service Provider.

YOU MUST SCROLL DOWN AND READ THIS ENTIRE DOCUMENT BEFORE LOGGING ON

Massachusetts General Hospital - Official Disclaimer and Privacy Policy

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- MGH is offering these interactive programs for educational, patient care, and research purposes. We expect all users to use the programs lawfully and appropriately. MGH has no

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- If you wish to remove any information you have submittedto this site, we will make reasonable efforts to accomodate your request. Please contact John Lester at lester@helix.mgh.harvard.edu. There is no need to "remove" any posts you make in these chatrooms, since chatroom messages are NOT saved or archived in any way (unless explicitly stated otherwise).

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Privacy Policy

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You may use the MGH web site without disclosing personally identifiable information. We want to be clear that we will not obtain such information about you unless you choose to submit it to us. For example, if you email your comments, that identifies your email address. If you request an appointment with a physician, a limited number of hospital administrators and health care providers will see this information and use it to arrange care where appropriate.

We have taken reasonable steps to ensure the integrity and confidentiality of personally identifiable information that you may provide. You should understand, however, that electronic transmissions via the internet are not necessarily secure from interception and so we cannot guarantee the security or confidentiality of such transmissions.

The web server of the MGH web site collects and saves the default information customarily logged by World Wide Web server software. Our logs contain the following information for each request: date and time, originating IP address and domain name (the unique address assigned to your internet service provider's computer that connects to the internet), object requested, and completion status of the request. We use these logs to help improve our service by evaluating the "traffic" to our site in terms of number of unique visitors, level of demand, most popular page requests, and types of errors.

These logs may be kept for an indefinite amount of time, used at any time and in any way necessary to prevent security breaches and to ensure the integrity of the data on our servers.

Please note that we use "cookies," which are small files stored on your computer's hard drive that are used to track personal information. We may use this information to save username and password data when you are accessing interactive parts of our websites, to allow your web browser to "remember" who you are and assist you by "logging on" without you having to type your username and password repeatedly.

Except for authorized law enforcement investigations or other facially valid legal processes, we will not share any information we receive with any parties outside of Partners.

By joining this chat, you acknowledge and agree to the terms of the above document.

Yahoo! - Help

Welcome back!

Verify your Yahoo! password to continue.

Return to Yahoo! Groups

Yahoo! ID: **mikelob2003**

Password:

Continue

Mode: Standard | Secure

Sign in as a different user

Why am I being asked for my password?

- To protect your account, you need to confirm your password periodically. (more)
- Only one account can be signed in at a time. If you're not "mikelob2003", sign in with your own ID.

HAROLD'S STORY

This is Harold's Story written by his son Cory

The location of the accident was in Alto, New Mexico, which is located in the most southern part of the Rocky Mountains approximately 5 miles north of Ruidoso.

The weather that day was a typical summer day. Cool in the morning and warmer in the afternoon. Ruidoso is known for it's afternoon showers in the mountains. I personally have witnessed the afternoon showers and thunderstorms. However, they were always fast moving and never stayed long. Matter of fact, my family was vacationing in Ruidoso just the week before the accident. My dad and I played golf all week long, and we took my kids fishing. The weather stayed constant all week long. The Thursday before I left, we were on the golf course when a thunderstorm developed. You could hear the thunder and see the lightning, and it was close. My dad starting talking about Lee Trevino being struck by lightning. He leaned over to me and said "I wonder what the odds are of being struck by lightning" and just kinda chuckled as we drove off in the golf cart.

My family and I headed back to Texas on Sunday the 14th, the accident occurred the very next day, a day that I will never forget.

My father and his friends had just completed a round of golf, and were waiting until noon to sign up for a tournament. They decided to practice their putting, while they were waiting.

According to a eye witness, he said at approximately 11:45 am, he saw a tremendous flash of light. When he looked up, he saw white smoke that encompassed the green. The eye witness was approximately 200 yards or less from the putting green. He called 911 from his car, he saw several people that were injured on the green. He told me that when he saw my dad, that there was smoke coming from his body, and that his clothes were on fire.

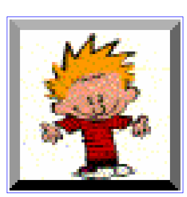
CPR was administered to my dad, several bystanders were helping others that were not as severe as my dad.

The paramedics arrived at the scene and quickly determined that he had no pulse or heartbeat. They indicated that he was in asystole and v-fib. They immediately shocked his heart with the defibrillator and his heartbeat returned. During the transport to the hospital they had to shock his heart two more times. He was stabilized at the Ruidoso hospital. He was then taken by care flight to the burn/trauma center in Albuquerque. He was breathing by the use of a ventilator, that would soon be placed in his trach. He was on the vent four weeks. He did regain consciousness three days after the incident. But, he was not responding to questions or anything that the doctors tried. He also had skin graph surgery, to repair deeply damaged tissue in his right arm and shoulder. A few days later his heart started beating out of normal sinus rhythm. They had to perform a procedure called cardioversion (electrically shocking the heart).

He currently has a permanently damaged heart, his heartbeat has to be regulated through medication. The worst thing possible, that could have happened, did. My dad went without oxygen to the brain (anoxia) for an extended period of time. He also lacked an ample supply of blood to the brain. He has severe brain damage to the front left lobe. This particular part of the brain controls reasoning, memory (short and long), and communication skills.

After two months in Albuquerque, he was care flighted to Baylor Medical Center in Dallas, Texas. He spent approximately 4 weeks in a skilled nursing center. He still did not know who he was or who the family was. My father spent the next sixty days in rehab, but the doctors determined that he has lost practically all of his short and long-term memory. He cannot walk due to the brain damage and nerve damage in his legs and spine.

He is currently at home, where my mother takes care of him. He requires 24 hours a day care.



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MY STORY

This is a photo of me. Did you expect a picture of a person with burn scars or perhaps missing pieces? Most people when they hear that I was struck by lightning are surprised at how NORMAL I look.

One common myth that's makes getting proper medical help for a lightning strike victim difficult is the 'crispy critter' myth. The myth being that when you're struck by lightning you're immediately burnt to a crisp and that if you survive without obvious external injuries then you are very lucky and will be fine. But lightning and the human body have a unique interaction that is different from other types of materials. When lightning hits a tree it blasts the tree apart but when it hits a human body it travels over the surface of the skin, this is called the flashover effect. This makes it possible for a person to be seriously injured but have little if any burning on the skin. Hence the crispy critter myth is thrown out the window.

The Day My Life Changed Forever

On August 6,1997, Vancouver was visited by a viscious torential downpour. Vancouver gets alot of rain but not usually in the form of a tropical storm and with this storm came thunder and lightning. The likes of which I have never encountered in Vancouver in the past 20 years that it has been my home. The city had over 2000 strikes in 3 hrs.

Having spent my first 10 yrs of life in Edmonton, I was not new to these kinds of storms. Since awe inspiring thunder and lightning shows were a common site on the Albertan prairies, I used to watch from the front bay window as sheet lightning filled the sky above the vast fields outside our home. I loved them, they filled me with excitement and wonder.

Somewhere in time, as I grew up living in Vancouver, I developed a fear of thunder and lightning, it wasn't a disabling fear but I always felt very uncomfortable when the rare storm struck. Perhaps it was because Vancouver got the more tranditional lightning bolts rather than the sheets I was used to seeing on the prairies. And Strikes we're always so much closer and louder than I ever recalled from my childhood.

I worked at an automotive repair shop as an apprentice mechanic. (I only had about a year more of practical work I had to complete before I would be ready to get my journeymanship). My husband also works there as a licensed mechanic. It was his day off the day I was struck.

The rain was beating down fiercely and the whole building boomed every 5 minutes or so as lightning was striking all around. The guys found it quite funny because every time there was a really loud thunder clap I'd jump or sometimes scream from being startled. We were all having a good laugh about how thunder scared me. The humor helped me keep my fears at bay and it was turning into a scary but sort of fun kind of day. I knew that people could be struck inside a building and I quoted to the guys lightning facts that I knew, using these as stress relief. We comforted each other knowing that our building wasn't tall and if lightning was going to strike it would strike something higher in the neighbourhood well before it got our building. (We found out that the myth lightning strikes the tallest object in an area is NOT true.)

I was working on a vehicle and John our boss came by to see how I was doing, he laughed as I jumped from another thunder clap and he said "I don't care if it hits something as long as it doesn't strike me" I replied "Well if anyone in the shop will be hit, it'll be me." We all laughed and agreed because everything that happens at work always seems to happen to me. All my life I have always had the strangest luck. But never in a million years did I honestly think I would be struck by lightning, and definitely not inside a building.

I was using the vice on the metal workbench at the far side of the shop. Above this bench are all the three phase circuit breakers for the shops electrical system. I took the aluminum thermostat housing out of the vice and had just stepped back from the bench when BOOM!

All I remember was seeing a blue flash between my outstreched hand and the bench and feeling intense pain engulf my hand. The rubber glove on my hand hand had the fingers blown right through and later looking at my left boot the rubber sole had melted in a few spots.

(Now the next few events happenned in a very short time frame and pretty much at the same time.) I was literally stunned, frozen mentally and physically, my muscles started twitching, my heart spasming, then the pain which was only in my hand at first climbed up my left arm and down the left side of my body. Over a period of about 20 mins the area that first had hurt went totally numb and I started becoming paralyzed but only on my left side. While this was all going on, a customer who was 20 ft from me at the time of the strike came running, asking if I was alright, he said he saw a bolt of lightning jump the 3 foot air gap from the metal bench to my arm. I just kept ranting "I was hit by lightningI was hit by lightning!" over and over in a very distressed freaked out voice.

The guys in the office when they heard the bang looked out and the whole shop was filled with blue light. They thought something like a propane tank had exploded from the sound the strike made. John came down to check me over at this time I could still walk and talk, Ed took care of me while John went to call 911. The phones were dead! Lightning had blown the phone system. (I later learned, when I got to the hospital, that Ed had been struck too. He was on the phone, it blew the receiver up and left a burn on his chest.) They didn't know what to do, they figured since I was still alive I wasn't in immediate danger, it didn't take long and the phones were working again and when they called 911 it was BUSY!

By this time I had taken a really bad turn for the worse I was turning grey, I couldn't walk and my whole left side was partially paralyzed, I was in excruciating pain and my breathing was stopping. It was so strange because I was conscious, sitting down and then suddenly I noticed something was wrong but I couldn't figure out what it was, and then I thought "Oh my god, I'm not breathing." I'd think "inhale" but nothing happened, then suddenly I'd be breathing normally again, and then it would stop. The times it stopped seemed like forever but in reality they probably weren't more than a minute. John finally threw me in a car and took me to the hospital. My breathing finally normalized about an hour after getting to the hospital. Ed was the next to come in, they put him in a bed beside me. We thought the whole thing was too funny.
It was only once the choas of it all subsided and the doctors started checking me out that the revelation came to me how serious the experience was.

Please ComeBack and Read the rest of my Story, I've not quite finished it yet.

This page is under construction.

Please come back soon.

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DAVID'S STORY

The date was 8/29/92 at around 4:00pm (give or take). I was on Duty as an Emergency Medical Dispatcher, on a 911 Phone Line, talking to a man in a burning building started by lightning. As I was giving Him instructions on how to safely exit the building (He needed a fire extinguisher to do it), I felt a very, very hot "Spark-Plug" type feeling inside my head, and tasted "Metal" in my mouth. I was tossed about 10-15 feet back to the wall of the Dispatch Room. I don't remember anything for about 30 minutes or so (can't really tell how long). I was taken to the hospital, where the Medics, my Father, and the ER Doctor saw blood coming out of my left ear. I had the worst headache I could imagine, and that "metal" taste made me sick. I spent the rest of the day in the ER to make sure my heart was "running OK", and sent home to rest a couple days (forgot how long). I returned to work a few days(?) later, and thought nothing of it.
I do know that the "Metal" taste stayed with me for a day or so. Tasted like I was sucking on a Copper Pipe or something.

After a period of time (?), I noticed things were not right. I lost some hearing in my left ear, and was dizzy most of the time, forcing me to take more time off from my dearly loved job. Then the Memory part. First it was forgeting what I was saying in the middle of a sentence, then forgetting what people were saying to me.

After more time, I forgot my Mother who died in 1991, and most of my Military and Childhood memories. Thanks to a classmate, I have been told alot of things about what we used to do.

My left ear kept "ringing" and "roaring" like a loud ocean, making me vomit without warning. Grossed out some guests a few times.

I had all the tests, MRI, ENG, CAT, BAER....All showed "abmormal results". The doctors didn't know what to do with me, until I went to one of the top "Docs" in Florida. They said I would have permanent problems with "balance", "Vertigo" and "Headaches".

This set me back. I was so active. I taught CPR since 1981, rising to the area Board of Directors with the American Heart Association, and running 3 "Training Centers" for CPR Instruction, keeping track of over 300 Instructors. I too was in Law Enforcement all during my Military Service, joining various Police and Sheriffs Departments for training, while I got my education. I was a Certified Substance Abuse Counselor in the Navy, and held a Top Secret Clearence +. I worked in Security Consultation and Managment for some large Corporations, and kept track of Million Dollar Budgets for various very up-scale communities.

I am a Life Member of the Police Hall of Fame, and served 12 straight elected years at Florida State Vice President of the American Federation of Police. Now, your wondering, if I have memory problems, how can I remember all of the above. Easy, I am looking at the Certificates on my Den wall.

As of this date of writing the following bother me:
1. Extreme Headaches
2. Vertigo
3. Left Ear Pain (deep) with "ringing" and "roaring"
4. Nausea
5. Vomiting
6. Memory problems
7. Get lost while driving in my town sometimes. (put a compass in my truck!)
8. Walk with a cane for balance control most of the time.
9. Hearing Loss (worse since injury in Left Ear)

As Time goes on, I feel worse, and the WORST SYMPTOM, besides the above is INSOMNIA!!! I go for days with no sleep, pacing the floors, laying in bed wide awake, etc.

I have an ENT and Neurologist (Specialists) and a regular Doctor. I went from making in about two weeks , what I make now in 1 Month in Social Security. Medicare Stinks; Prices go up, but not your Disability Payments.

My friends brought me a Radio Shack Lightning Rod to clip on my belt (as a joke), and call me "Sparky"....Well, I am electrically charged.(grin!) .
I try to laugh about it with others, but no one knows what you are going through EXCEPT another Survivor. Thank God for LESSI and this Web Page. I wish all out there the very best, and please feel free to email me...My friends have long since stopped coming or calling me. May God Bless each and every one of you out there.

David A. Smith ke4uei@gate.net
Stuart, FL

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BAILEY'S STORY

Bailey is a list member on The Lightning Strike Survivor List

I was struck by lightning in 1993 while I was living in Atlanta, Georgia.

I was working on the motherboard of a computer and a sudden severe summer storm blew in. I saw a bright hot flash and the next thing I knew I was stuck to the board and felt like a hot piece of charcoal. I knew that I had to pull my hands away and I finally did.

People around me said that a blue arc of light went from the board to my fingers and then my chair was blown back about 10 feet. The heel of my left shoe was burned off and the computer was a smoking heap.

I went to the emergency room where my heart was monitored because it was erratic. At this point, I was not able to see out of my left eye and both arms were totally numb. My heel was burned also. I stayed the night and was released the next day.

Now, six years later, I have no feeling in my left arm from the elbow down and I suffer severe migraines often. I suffer these headaches especially bad when the barometric pressure changes. I gained the ability to predict storms about two days ahead if they are connected to a strong front.

I am left-handed and have had to learn many things over again. I am in law enforcement so the use of my left hand is important.

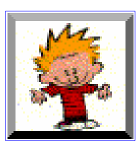
Luckily I have the support of my wonderful husband and my loving family. I have a great neurologist and support staff His nurse, has been a wonderful help in making me see that I can move on and live.

I know that I am lucky to be alive and I am thankful for that and for finding the Lightning Strike Email Support List.

I am scared of storms but between my husband and my cat, they keep me sane!

Thank you all for listening to me and letting me know that there are others out there going through the same and sometimes worse problems that I am! I would love to hear from anyone who would like to share stories and sometimes complaints with me!

GunlvrBabe@aol.com



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HIT and MISS

A majority of these facts were taken from articles written by Dr.Mary Ann Cooper.They are available in full unedited form at:
The Lightning Injury Home Page

I in no way want to take any credit for the writing and information here. I just gathered the info that I felt was most useful to people wanting to understand lightning injury and strikes and have included it on my page. Dr.Cooper did most of the work and she has my utmost respect and thanks.

The Facts and Myths about Lightning and the people it Injures

Among the myths about negative effects is the "crispy critter" myth. This is the belief that the victim struck by lightning bursts into flames or is reduced to a pile of ashes. In reality, lightning often flashes over the outside of a victim, sometimes blowing off the clothes but leaving few external signs of injury and few, if any, burns.

Myth:
I will probably never know a victim of a lightning injury because they are so rare.

Fact:
The odds of being struck are 1 in 600,000. You are more likely to meet a lightning strike survivor than you are to meet a person who has won the lottery.

Myth:
No one injured by lightning lives to talk about it.

Fact:
The estimate of deaths by lightning is about 3 to 10% of all incidents. There may be as many as 750 to 5000 injuries per year.

Myth:
"When lightning hits the ground nearby, it is 'grounded ' and I am safe. "

Fact:
Despite the fact that we call the earth a "ground," it is very difficult to pump electricity into the ground. Most "earth" is a very good insulator. When lightning hits the ground, it spreads out along the surface and first few inches of the ground in increasing circles of energy called "ground current." If it contacts a fence or a

water pipe or wire entering a house it can be transmitted for quite a distance and cause injury to persons near these paths. The human body is made up of primarily water and salts this makes us basically bags of electrolytes. This makes people better transmitters of electrical current than most ground is, and many are injured by ground current effect each year as the lightning energy surges up one leg that is closer to the strike and down the one further away.

"My mother always told me to stay off the telephone (out of the bath tub, away from windows, unplug the appliances, etc.) during a thunderstorm. "

Good advice, if not always practical. Again, the ground current effect of energy transmitted into the structure along wires or pipes may find the person a better conduit to ground. Many injuries occur every year totelephone users inside the home.

Myth:
Most lightning injuries occur on the golf course.

Fact:
Lightning has injured many people who have been in buldings which were struck. The lightning flows through the building to ground and if a person is in the path to ground they get struck. Many times the strike doesn't do any external damage to the building because it travels through the wiring and the metal pipes, but still the occupants can get struck. Particularly if they're holding or near wiring, pipes, and other metal objects.

A large number are work-related. These include injuries to postal and construction workers and persons using telephones that have not been properly grounded.

Injuries during recreation occur to joggers, hikers, and campers, as well as golfers. In addition, a significant number of people are injured while participating in team sports.

Myth:
Some people can attract lightning.

Fact:
Some have called themselves "human lightning rods," claiming that thunderstorms would change course to find them or that they had been struck multiple times. With lightning victims, some may suffer little injury from a single strike, but the majority have some type of injury complaint. When one claims to have been hit 20 or more times, the odds of being able to talk about it decrease logarithmically. Would any reasonable person not have enough sense to learn to avoid lightning after the first couple of hits?

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Please come back soon.

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What Injuries do Lightning Survivors Experience?

Lightning Strike Survivor Max Dearing answers this question with the following excerpt he wrote for LSESSI's web page. I have included my personal experiences as well, inserted among his article. My contributions are colored red.

While not every survivor will experience everything below, most of themare common items. I have experienced most of the effects below at some point or another. Some have become miniscule while others still persist. At any rate here's the list:

Long term memory loss. - You don't even know what's gone until you try to recall it. I know that most of my childhood memories are gone.

I too, am missing significant pieces of my memories before my Lightning Strike. The other day I was looking at photographs of myself and friends at a car meet. I felt sad. Everyone looked like they were enjoying themselves and having fun. But I didn't remember even being there. Even the background was oddly unfamiliar. It was a strange and eerie experience. (May 7/99)

Short term memory impairment. - Usually attributed to old age. i.e.Get up to get or do something and forget what it was. Except this can happen as many as a dozen times a day, or more.(I'm 39 years old and other survivors are far younger than I who complain about this symptom.) It doesn't always happen every day. So the unpredictability is also a factor.

Everything Max wrote describes my experiences with memory as well. Over time the frequency has diminished but I still can't find things I put away 30 mins ago, I can't remember telephone conversations as soon as I get off the phone. This doesn't happen everyday but happens enough that I can't rely on what I remember.

I still put the milk in the cupboard and the clean dishes in the oven. Our house is a fun place for our friends, they're always getting a laugh from my foibles.

Just 2 days ago I did a first: I forgot to take the money from the bank machine after I withdrew it. Fortunately the guy after me was honest and I was able to go back and get it. (May 7/99)

Sleep pattern disturbances. - Sometimes you want to sleep for days. Sometimes you can't sleep for days. Sometimes 15-20 minutes of sleep, and you're good to go for another 36 hours. Another thing that can happen is, when you are just about at the point of sleep and any slight noise will wake you up. When this occurs, you feel as though you've had two days rest, and are ready to go for another 10-12 hours.
Often after getting as much sleep as you can get, you still have severeproblems getting up and getting motivated because of complete exhaustion.
Most of the time I get 2-3 hours of uninterrupted sleep. Occasionally, I can sleep for 6 hours. I have not been able to sleep any longer than 7 hours in almost two years.

Sleep problems have been an on going battle for me as well. I suffer primarily from fatigue. I just want to sleep and sleep and sleep, but sleep doesn't seem to help make it go away.

Fatigue is a common symptom of any brain injury. Lightning survivors typically have frontal lobe brain injury and the problems Max is describing in this page are consistent with these injuries.

I also have trouble falling asleep it can take me 4 or 5 hrs to actually fall asleep even though I am so physically exhausted that I can't do anything except lie there and wait for sleep to come.

I suffer from night sweats. Actually I call them just 'sweats' because I will sweat even during a nap in the day time and while I'm awake. My body temperature regulation is out of whack. My body temperature swings very high to very cold. When it swings high I sweat. When it swings low, it can be 30C/90F inside my home and I'll still have to turn the heat up. (May 12,1999)

Clinical Depression. - Many, if not most, survivors are treated for depressed mindsets. Often the medications work, but for only a limited time.

Irratic Cognitive thinking impartment. - Though still functional in a work or social environment, the ability to rationally communicate in conversation sometimes is difficult. The telephone represents an even bigger challenge. You hear the words, know what they mean, but still can not put the thoughttogether that means anything that is relevent information.

Numbers or numeric processing is sometimes also effected. Additionand subtraction abilities may be gone or severely disrupted (as in my case) but complex division is still intact.

Other effects may be just the opposite. Many physicians may falsly attribute this to early onset of Alzheimers Disease.

Irritability. - Primarily brought on by knowing that you are impaired but cannot communicate it in an intelligent manner, or that you can't relieve or fix the situation.

Muscular and Central Nervous System problems. - Another problem which is attributed to the aging process. Sudden sharp stabbing pains in muscles, joints or tendons. Atrophied muscular groups cause a constant feeling of exhaustion. Some may just call this laziness.

Headaches - Sometimes severe blinding Migrane's. Often, closely experienced "Cluster" headaches.

Headache Relief: Several people have found relief with acupuncture. The National Institutes of Health have recognized acupuncture as indicated for the treatment of several different neurologic things such as headaches and stroke. (Just thought I'd include this info. Who knows it may help someone. July 16/99)

Loss of dexterity and fine motor skills. - Difficulty in typing,buttoning buttons, etc...

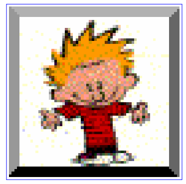
Vitamin B6 & B12 Deficiency. - Vitamin deficits can cause all sortsof problems, and the B complex vitamins are necessary for central nervous system health.

Hearing deficits and impairments.

Seizures - Often associated with closed head injuries. It seems that many more electrical shock victims experience sezures than lightning victims. Most survivors indicate that standard medications are reasonably effective, but not totally.

As I find time this page will be updated so...

Please come back soon.



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This Article Published by NASA Space Science News is excellent. As it has much information in it that I wish to share, rather than repeating myself and others I have copied it here.

SPACE SCIENCE NEWS
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Human Voltage

What happens when people and lightning converge

One of a series of stories covering the quadrennial International Conference on Atmospheric Electricity, June 7-11, 1999, in Guntersville, Ala.

June 18, 1999: Either lightning is attracted to testosterone, or men spend an inordinate amount of time outdoors swinging metal objects about. Men are struck by lightning four times more often than women.

According to a study entitled "Demographics of U.S. Lightning Casualties and Damages from 1959 - 1994," by Ronald L. Holle and Raúl E. López of the National Severe Storms Laboratory and E. Brian Curran of the National Weather Service, males account for 84% of lightning fatalities and 82% of injuries.

Men can take comfort in the fact that the actual number of deaths and injuries from lightning strikes has decreased in the past 35 years. Holle's team attributes 30 percent of the decrease in lightning deaths to improved forecasts and warnings, better lightning awareness, more substantial buildings, and socioeconomic changes. They attribute an additional 40 percent to improved medical care and communications.

The National Weather Service publication *Storm Data* recorded 3,239 deaths and 9,818 injuries from lightning strikes between 1959 and 1994. Only flash floods and river floods cause more weather-related deaths. But according to Dr. Elisabeth Gourbière of the Electricité de France, Service des Etudes Médicales, only 20 percent of lightning victims are immediately struck dead. Still, many doctors do not fully understand how to treat the injuries of the other 80 percent

Recent Headlines

August 19: Dashing and Coasting to the Interstellar Finish Line

August 18: Just Passing By Earth

August 17: Cassini & Polar Join Forces to Study Earth

August 16: Planet in a Test Tube

of lightning victims who survive a strike.

Says Gourbière, "The pathology of lightning, or keraunopathy, is known only to a few specialists."

Most doctors are more familiar with electrical shocks, such as those received by industrial workers when they have an accidental run-in with high-voltage equipment. But lightning injuries are not the same as electrical shocks. For one thing, the contact voltage of a typical industrial electrical shock is 20 to 63 kilovolts, while a lightning strike delivers about 300 kilovolts.

Industrial shocks rarely last longer than half a second (500 milliseconds) because a circuit breaker opens or the person is thrown far from the live conductor. Lightning strikes have an even shorter duration, only lasting up to a few milliseconds. Most of the current from a lightning strike passes over the surface of the body in a process called "external flashover."

Both industrial shocks and lightning strikes result in deep burns at point of contact - for industry the points of contact are usually on the upper limbs, hands and wrists, while for lightning they are mostly on the head, neck and shoulders. Industrial shock victims sometimes exhibit deep tissue destruction along the entire current path, while lightning victims' burns seem to center at the entry and exit points. Both industrial shock and lightning victims may be injured from falling down or being thrown, and the leading cause of immediate death for both is cardiac or cardiopulmonary arrest.

If you survive a shock, you still have to deal with the consequences of the electrical burns. Industrial shock burns can lead to kidney failure, infection, muscle and tissue damage, or amputation. Lightning burns are exceptionally life threatening (see box at the end of this story).

Right: High voltage electrical equipment can cause severe shocks and burns slightly similar to those from lightning strikes.

Gourbière says that 70 percent of lightning survivors experience residual effects, most commonly affecting the brain (neuropsychiatric, vision and hearing). These effects can develop slowly, only becoming apparent much later.

Feel the Burn

If you'd like to experience a lightning strike, go golfing one Sunday in July around 4 p.m. If you're really determined, be sure you do it in Florida.

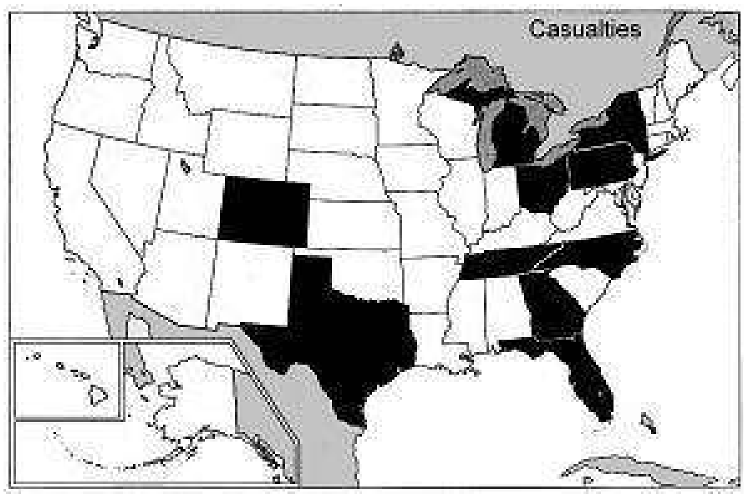
Florida has twice as many lightning casualties (deaths and injuries combined) as any other state. Most lightning casualties occur in the afternoon - two-thirds between noon and 4 p.m. local standard time with a casualties maximum at 4. Sunday has 24% more deaths than other days, followed by Wednesday. Lightning reports reach their peak in July.

Many lightning victims had been walking in an open field or swimming before they were struck. Other lightning victims had been holding metal objects such as golf clubs, fishing rods, hay forks, or umbrellas. But even those not holding metal objects are as likely to be struck by lightning as a bronze statue of the same size.

When you hear thunder, you are already within the range where the next ground flash may occur. N. Kitagawa of Central Lightning Protection, Inc. and A. Sugita and S. Takahashi of Franklin Japan determined the average intervals between lightning strikes in order to estimate how much time someone has to seek shelter. Their news is far from encouraging.

"It is concluded that there exists no safe time interval during which a human is free from direct strikes," they wrote.

In an area with a radius of 500 meters (1,640 ft), most of the intervals between lightning strikes range from 0 to 600 seconds, with a maximum frequency of 40 seconds.



Right: The top ten states in number of lightning casualties (deaths and injuries combined). Florida leads the list, with twice as many casualties as any other state. Other states represented are Georgia, Tennessee, North Carolina, New York, Pennsylvania, Ohio, Michigan, Colorado and Texas.

To avoid being struck by lightning, you should seek shelter when you hear even the faintest thunder. Some of the best places to take refuge are enclosed buildings, or cars and buses (but don't touch the metal!). In case there are no safe spaces nearby, bend into a crouching position until there is a break in the storm.

Web Links
Lightning Strike Survivors Resource Page - links to survivors' stories and other lightning pages.
National Lightning Safety Institute
National Severe Storms Laboratory
NASA's Global Hydrology and Climatology Center - Lightning and atmospheric electricity research.

Isolated trees, telephone booths, and open structures like gazebos or porches make poor lightning shelters. If there is a tall object nearby, move as far away as possible - at least 2 meters (7 ft). Standing next to tall isolated objects like poles or towers makes you vulnerable to secondary discharges coming off those objects.

According to L.G. Byerley III from Lightning Protection Technology and W.A. Brooks, R.C. Noggle, and K.L Cummins from Global Atmospherics, Inc., the growth of towers in the United States has increased the amount of lightning strikes in certain areas. Such towers include cellular telephone and wireless communications, radio, microwave repeater, VHF communications and water towers.

The mechanism for how towers attract lightning is not really understood. But scientists have known for a long time that towers attract more lightning than the undisturbed ground nearby.

The tale of a family in North Carolina clearly illustrates how towers can concentrate lightning strikes. In 1998, a 42 meter (138 ft) tall water tower was erected near Murfreesboro, NC. This tower was about 45 meters away from a farmhouse that was situated on a one acre plot in a large open area of farmland. The family had lived in the farmhouse for the past 10 years, and they had never experienced any lightning damage. After the tower was erected, 5 separate discharges near the house occurred over a period of 5 months, causing the deaths of 2 trees, a fire in electrical equipment, complete destruction of all phone wiring, and damage to electrical fixtures.

Right: Lightning flirts with a 335-ft tall radio tower. Credit: Jeffrey K. Herzer/Missouri State Highway Patrol Communications Division.

Lightning damages have been on the increase in the past 35 years. Holle's team attributes most of this increase to population growth. *Storm Data* recorded 19,814 property-damage reports due to lightning in the United States from 1959-1994. Pennsylvania has the largest number of damage reports, while the highest rates of damage reports weighted by population are on the plains from North Dakota and Oklahoma.

According to Richard Kithil of the National Lightning Safety Institute, most reports of the economic impact of lightning are contradictory and underreported. The National Weather Service *Storm Data* figures place the most recent yearly losses at $35 million, but the process by which this figure is tabulated is open to error. *Storm Data* collects much of its severe weather information from newspaper reports. If an incident is not reported in the paper or is

overlooked by the *Storm Data* reviewer, it may not get into the publication's statistical base.

Kithil conducted his own study based on insurance reports and other sources that keep track of weather damages, and he came up with a much larger figure for the annual cost of lightning strikes.

"It seems reasonable to estimate that there may be $4 to 5 billion in lightning costs and losses each year in the US," said Kithil.

There are currently several different methods used to keep track of lightning strikes, but none of them can be considered perfect. Medical reports, for instance, sometimes report "burns" as the primary cause of death, with lightning listed as a secondary effect. Despite such instances of underreporting, the methods used in the United States to track lightning strikes are considered to be the best available.

"We work with people from other countries who wish they had what we have," said Holle.

Humans versus Lightning

To stand against the deep dread-bolted thunder?
In the most terrible and nimble stroke
Of quick, cross lightning?
(Wm. Shakespeare, "King Lear", Act 4, Scene 7)

Right: Photo Credit: Australian Severe Weather/Michael Bath

In the contest between people and lightning, lightning wins. Although lightning rarely strikes more than one person at a time, over the course of a year the damages, deaths and injuries add up to make lightning a serious threat. By studying the outcome of human-lightning encounters, scientists hope to find more ways to prevent such meetings from occurring in the first place.

Most Typical Disorders Associated with Lightning Strikes

(from "Lightning Injuries to Humans in France" by Dr. Elisabeth Gourbière of the Electricité de France, Service des Etudes Médicales)

Lightning deaths (~20%)
-Asystole/Ventricular fibrillation
-Inhibition of brainstem respiratory centers
-Multi-system failure (delayed death)

Cardio-pulmonary injuries
-Arrhythmias - Arterial pressure changes

-Electrocardiographic changes
-Myocardial damages (infarction)
-Cardiac dysfunction
-Pulmonary edema - Respiratory distress syndrome

Neurologic/psychiatric injuries
-Loss of consciousness/coma
-Amnesia/Anxiety/Confusion/Aphasia/Seizures
-Electroencephalographic abnormalities
-Brain/Cerebellum damages
-Numbness/Weakness in limbs/Partial or complete (but temporary) paralysis
-Neuropathy/Pain syndromes
-Spinal cord injury/Parkinsonism
-Sleep and memory disorders/Concentration disturbances/Irritability/Depression/Various other disturbances such as headaches, tiring easily, lightning storm phobia, etc.
-Post traumatic Stress Disorder

Burns and Cutaneous marking
-Small, deep entry/exit points (typical)
-Contact, metal chain heating (typical)
-Superficial linear
-Flash
-Lichtenberg figures (arborescent, fern-like markings):pathognomonic(on trunk, arms, shoulders)

Clothing, shoes
-Exploded off, torn off, shredded, singed…

Blunt traumas (explosion)
-Contusion, internal hemorrhage (brain, lungs, liver, intestine…)
-(rarely) Fractures (skull, cervical spinal column, extremities…)

Auditory and ocular injuries
-Tympanic membrane ruptured (typical)
-Deafness/Tinnitus/Vertigo
-Transient blindness/Photophobia-Conjunctivitis - Corneal damage
-Retinal abnormalities (macular hole) - optic neuritis
-Cataract

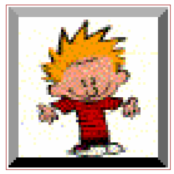
"Lightning injuries are varied and take many different forms. The most dangerous (and possibly fatal) immediate complications are cardiovascular and neurologic. It must be kept in mind that only immediate and effective cardiorespiratory resuscitation (started by rescuers), followed as soon as possible by emergency medical treatment, can save victims who are in cardiopulmonary arrest, or avert the serious consequences of cerebral hypoxia. Some victims remain in a coma despite intensive resuscitation and die of secondary causes including hemorrhages and multiple lesions (encephalic, cardiac, pulmonary, intra-abdominal)."

More links

National Severe Storms Laboratory, Norman, OK
National Severe Storms Laboratory Photo Library, where we got a lot of the neat pictures for these lightning stories.

Lightning research at NASA/Marshall and the Global Hydrology and Climate Center.

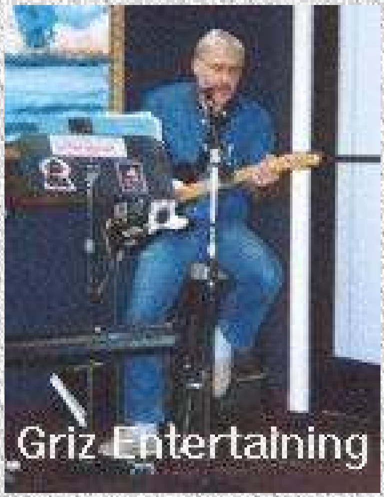
For more information, please contact: Dr. John M. Horack , Director of Science Communications	Author: Leslie Mullen Curator: Linda Porter NASA Official: Gregory S. Wilson

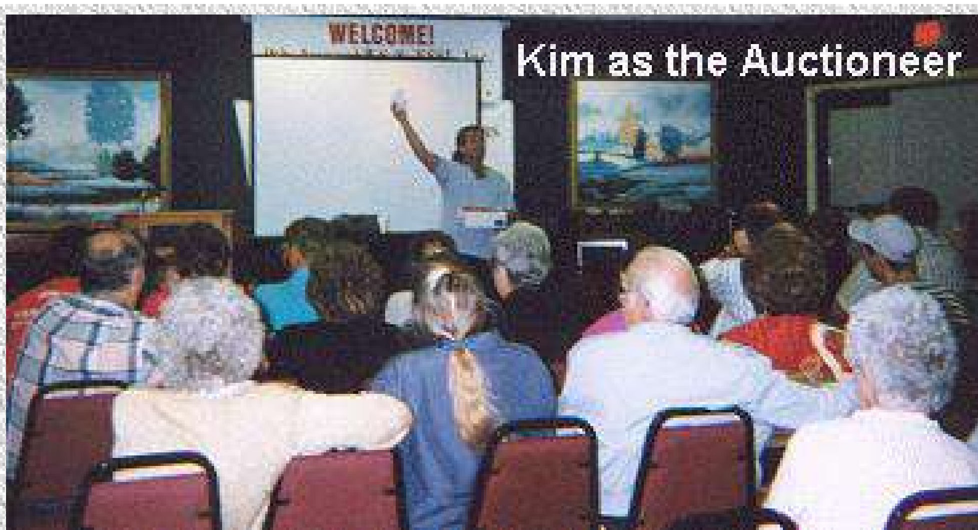


Back To Lightning Strike Resources on the Web Page

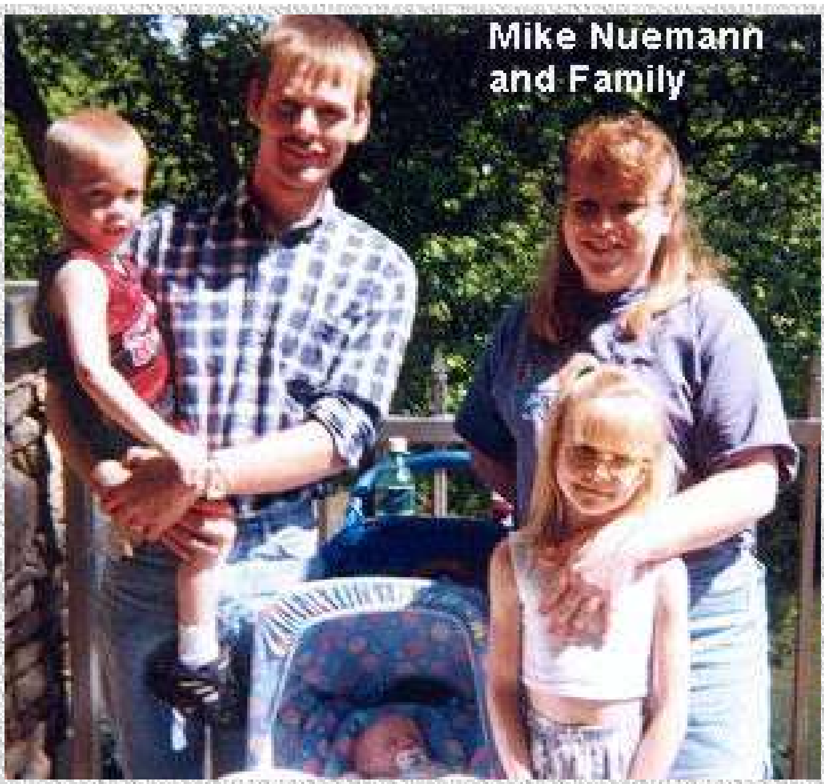
Here They Are!
Photo's from 1999's Lightning Strike and Electrical Shock Survivor's International Conference in Pigeon Forge, Tenn.

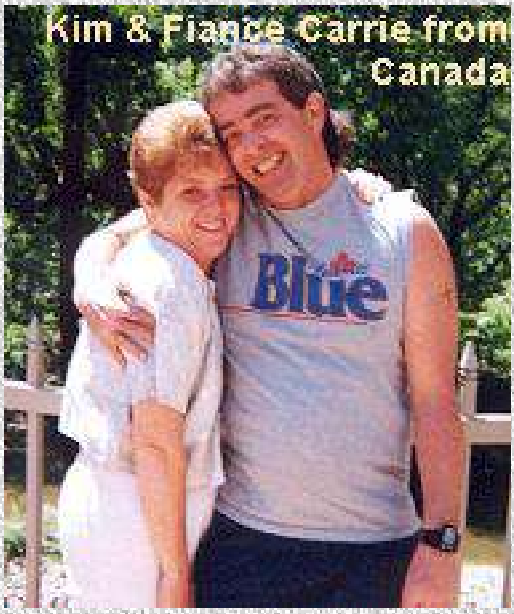
Sadly I wasn't there but I've booked my room for next year!




WELCOME!
Kim as the Auctioneer

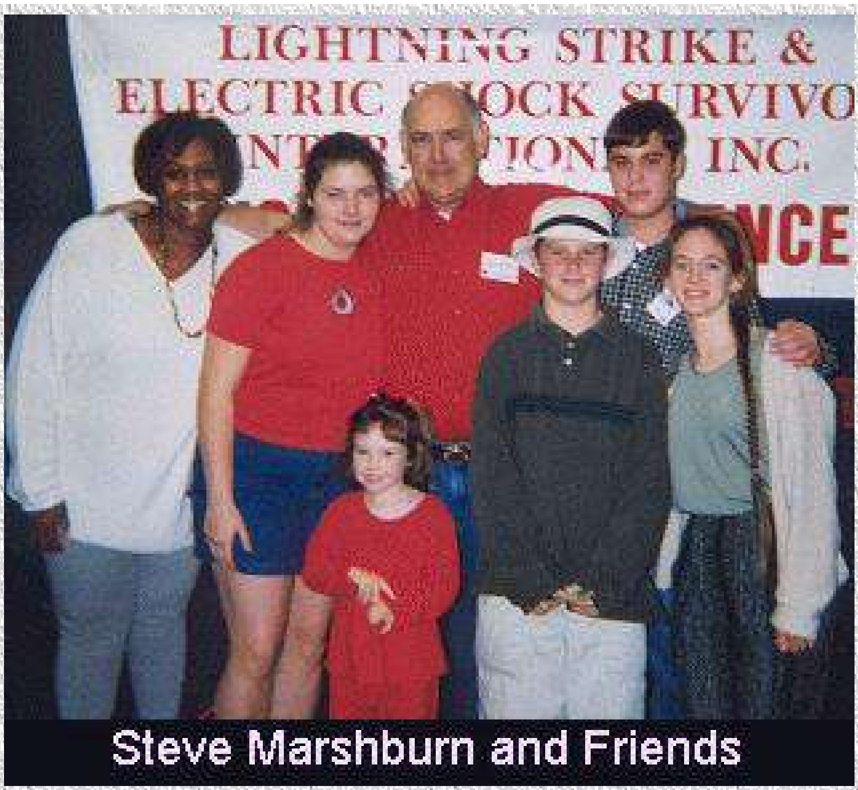

Joe Coldiron


Mike Nuemann
and Family

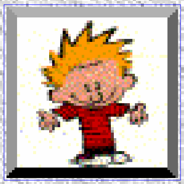

Kim & Fiance Carrie from
Canada
Blue

Steve & Joyce Marshburn

Ron Holle, Dr. Nelson Hendler, Dr. Mary Ann Cooper and her daughter Carley



Well that's all the pics I have. Thank You Becky for sending them. If you have any photos from the conference that you would like to share, email me at **christine_fram@telus.net** and I'd be happy to put them up.

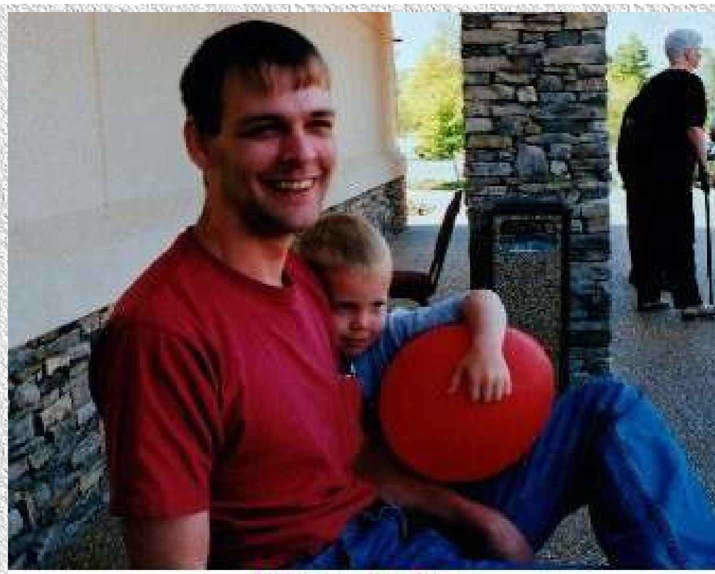


Back To Lightning Strike Resources on the Web Page

Photos, Photos, Photos!!!

I went to the 10th Annual Lightning Strike & Electrical Shock Survivor's International Conference in Pigeon Forge this past April 2000.

It was GREAT ! Plan to be there in 2001. If it's the only thing you do next year...
...It will still be the best thing you'll ever do!



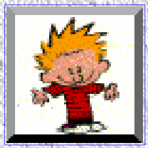
Mike and Son

Dr. Mary Ann Cooper Patrick
Me (Christine Fram) Patrick's Mom Kim

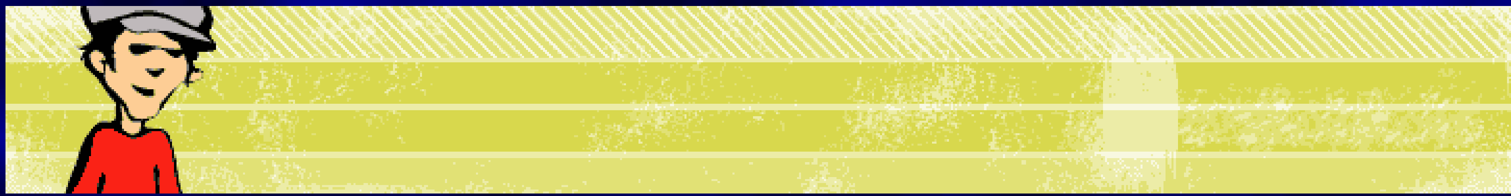
Iva

Sadly that's all I took!

If you have any photos from the conference, I would love to put them on here so please email them to me at **christine_fram@telus.net**



Back To Lightning Strike Resources on the Web Page



My Lightning Page

My Lightning Experience And Helpfull Links

- What Happened To Me
- The Lightning Survivors Group I Belong To
- YOU ARE NOT ALONE!

The above image is courtesy of my Spirit brother, Mike Pendergast, a very talented lightning photographer, and 2x survivor.

I do not recomend that anyone attempt to photograph lightning, under any circumstances, but Mike does take precations.

Thanks for the image, Mike!!!!!

You can see some of his others on his home page, you can find a link below.

This page is devoted to my lightning group and my own close encounter with a lightning strike in July of 1999 and again in October of 2000!

If you are a lightning survivor, and you feel that you want/need help, there is a link for the survivors group that I have joined, I have found these wonderful people to be a blessing, a source of comfort, and a great resource! Check them out!

Contrary to popular belief we are not ALL crispy critters, although that has happened!

A bit of cultural background...

I follow the ways of the Lakota Sioux, so this comes from that perspective.

The Thunderbeings are responsible for storms, and every so often, they single out certain individuals to become Heyoka.

They are (to over simplify things,) the sacred clowns who laugh on the outside while crying on the inside. They are the contraries, who sometimes do certain things backwards.

To create a heyoka, they will hit their human targets with lightning, or an individual will dream of the Wakinyan as they are called, during a vision quest.

I was hit by lightning.

I think that I always knew that I was a Heyoka, I do lots of things backwards. I can remember my father telling me (out of exasperation) that I MUST be a Heyoka after watching me do something REALLY bassackwards, LOL!

My first strike came down through the roof of the trailer I was living in at the time with my husband and 2 kids.

It missed the tree hanging over the trailer, it came down though the wall, into the dryer (I was changing the laundry over at the time, helpful hint, never do your laundry during an electrical storm!),entered my body through my right hand, through me, exiting through my left hand back into the dryer to exit out the dryer vent. It also managed to exit out an outdoor light fixture, and an electrical outlet.

There were scorch marks to prove that it really happened.

When I got hit, at first I was disorientated and had no clue as to what had REALLY happened to me! I went to the doctor the next day and was told that because I was not burnt, there was not much that they could do for me. I am still finding out what my side effects are, even after one year.

I have migraines,where I was not a migraine sufferer before my first strike, my dyslexia is more pronounced, I have spells of (for lack of a better word) "vertigo”, or extreme lighteadedness, and a mild ringing in my ears.

I also have a weakness in both wrists, (probably a side effect from the first strike's path) and chronic pain.

I get very antsy when there is a storm approaching, even when I do not know that one has been forecast, and have found this to be a very common thread with other survivors.

I also have a severe memory impairment. There are days that I am lucky to remember my own name, let alone what I was doing 5 minutes ago, and that is no exaggeration! My kids think it is funny, and while I can laugh about it, it is really very frightening and frustrating. It seems to be mainly my short term recall that is affected, I can remember 15 years ago a lot more clearly, and that is saying something as I am only 32 (10/08/2000)!

Please use the link for the lightning strike survivors page to check on other possible symptoms, if you are interested! It gives much more insight in to what we go through on a daily basis.

Many people who do not understand, assume that we are either faking or trying for sympathy.

Bullsh**.

This is very, very real.

A note of interest, about 15 months I was hit again in October of 2000 at about 2:30 am, local time. It flashed over the bladder of my water bed, and got me in the process.

The strike somehow hit my house, (We bought a 2 story early American/Federal style house in November of 1999,) and went through the electrical systems of the house, leaving all of the appliances and phones intact!

My son was sleeping with me, but seems to have suffered no damage, and my daughter later reported that she could feel a current through her metal bed bunk frame (the kind with the futon on the bottom...) and she too seems to have taken no damage. (We had them checked by a doctor who is familiar with my case.)

We are still trying to find out what was done to me, as I seem to have taken the brunt of the shock.

It is hard to tell what is from my first hit, and what is from the second. The sad part is that I am a bit of a rarity as there are not many people that get hit in Southeast Iowa, so the doctors are not sure how to treat my syptoms and problems.

When I told my husband about the second strike, he did not believe me! My daughter confirmed it later, in a separate conversation, and he STILL did not believe me! Men...

On a lighter note, it is fun to watch others move as far away from me as they can durring an electrical storm! My nickname at work is "the human lightning rod", but storms for me are not much fun anymore, and I have a much healthier respect for the power of a storm!

I now carry a mild charge, and get zapped every time I use a household appliance! It sure makes fixing a meal interesting!! It is also a lot of "fun" at the restaurant where I work as we have a lot of stainless counters, etc.

Update:

I have found a local Neurologist who is willing to treat my symptoms, and am now in a management program. Since I am so far post strike from both encounters, there is nothing that can be done for the original injuries, we can only treat the symptoms.

I am now taking Ametriptyline for the migraines, and paxil for the mood swings, time release B12, a good multi B, a good

Multi vitamin, potassium, and vitamin C.

I do not recomend these as a treatment for everyone, this is what works for me.

I will never be what I was before I was hit, and I can live with that. I have also learned that this has happened to me for a reason, and that I do not need others to belive in order to validate what happened to me. I know that it happened, and that is enough for me.

A note of irony, Mike Pendergast, (my spirit brother), how is also a very talented photographer, was hit for the second time about the same time as I was, and is slowly recovering from multiple burns and other effects. I feel for you, Mike! Be sure to visit Mike's home page using the link provided, you will be glad that you did!

Please come back to see how I and other survivors are faring!

Remember, we are not alone....Mitakuye Oyasin

My email address has changed, it is now spottedeaglehorse2@home.com Thanks!

Helpfull Links

My Links Page
Lightning Strike survivor and LS&ESSI (Lightning Strike & Electrical Shock Survivors
The Martin County Florida Sky Warn Home Page, Good Lightning Information Here!
Sam Silver Hawk
Lightning Strike Survivor's Resource Web Page
My Spirit Brother Mike's Home Page
My Other Lightning Home Page

PLEASE NOTE: This web page has moved to: http://www.kidslightning.info/sabintro.htm

Please use this link now for the most current information.

Lightning Safety for Kids: Introduction

TECHNICAL NOTES: **This web site is intended to be viewed without frames. If you see it in a frame or inside another web site, please click here.**

To enjoy the colors of this web site as they were created, click here for a simple MONITOR ADJUSTMENT.

Hello. My name is Sabrina. I was struck by lightning.

My mom and dad were hit too. We were hiking in a forest at the Grand Canyon and got caught in a storm. We hid in a side canyon until it stopped raining. Then we headed back to the car. My mom saw little birds flying and we stopped to look at them. We were all holding hands and WHAMO. I was so scared that I ran all the way back to the car. We were very lucky because we were not badly hurt. Since we were struck, I have been learning about lightning. I think that if we had known more about lightning, we would have known what to do and what not to do and we might not have been struck.

The reason that I made this web site is because it really hurts when you are struck by lightning and I want to help other kids to learn more about lightning safety. I want to share what I have learned with you. I

think that the more you know, the safer you can be.

This web site is for your whole family to read and you can share it with your friends and teachers. It has links to many other lightning pages that I hope will be interesting and helpful to kids. Some of them are really cool.

Follow this link to my Lightning Information for Kids pages.

Lightning Safety for Kids.

anubisbastet@earthlink.net

Welcome to the Home Page of the

MARTIN COUNTY, FLORIDA, SKYWARN ORGANIZATION

This Web Site is Dedicated to two fine people, whom have Passed-On; But their Memory will live Forever:

Mr. Robert W. Blackwell, W3HVS   Mr. Gordon "Gordy" Raspiller, KF4KCH

Atlantic Hurricane Season: June 1st through November 30th

The Martin County Skywarn Organization is an all volunteer Public Service Group Dedicated to Providing Local Emergency Weather Information to the National Weather Service, and When Requested, to All the Other Allied Emergency Operations Activities Within the County

Be "Lightning Safe" and "Learn How to Stay Safe"

The Purpose of Martin County Skywarn

Interesting and Informative Weather Sites

While You're Here, Please Sign Our Guest Book

View the Guest Book

For further information, please contact David Smith, KE4UEI, OES/ORS/OBS/, Martin County Skywarn Coordinator and Lightning Strike Survivor.

Send E-mail to Dave, KE4UEI

Page Updated: August 27, 2004

We're sorry!
The Webshots page you have requested has either moved or no longer exists.

Click here to visit the community.webshots.com or wait a few seconds and you will be redirected.

If you are looking for the Webshots Desktop Software, visit the download page.

STRUCK BY LIGHTNING

Primal and powerful, lightning is one of nature's gravest hazards. A new national detection system pinpoints almost every **flash**

BY DANE LANKEN

Christine Fram was struck by lightning on August 6, 1997, while inside a building, which is a relatively safe place, in Vancouver, where there is relatively little lightning. In that split second, she joined the 60or so Canadians who are struck by lightning each year. She was not among the six or seven who die but was among those whose lives were, as she says, "rewritten" by the experience.

Then 28 and an apprentice auto mechanic, Fram was standing near a metal workbench in the Grandview Tire and Auto shop on Commercial Drive. Lightning struck the power lines outside, surged through to an electrical box on the wall inside, travelled down to the bench, then jumped across a metre-wide gap to her left hand. She heard a bang and saw a blue flash. A man near her saw the bolt. A blue glow filled the room.

Fram felt pain in her left hand. There were holes in her rubber gloveS, and the rubber sole of her left shoe was melted. Her muscles twitched. Her heart beat irregularly. She was stunned and confused, having weird thought processes, feeling as if she wasn't breathing. Pain spread over her left side, then numbness. She couldn't walk. Her boss drove her to the hospital.

Stupendous bolts of electricity come hurtling from the sky roughly five million times a day worldwide. Considering that each thunderstorm - there are 2,000 in progress at any one time - produces thousands of flashes, it is remarkable that more people aren't injured or killed. Detection systems across Canada and around the world are now helping reduce that risk by sensing almost every bolt, logging its location, direction, timing and frequency, and thus improving our ability to forecast severe storms. We have by no means tamed this force of nature, and we still have much to learn about its impact on humans, but we do know how much damage a bolt can cause and how to protect ourselves.

With its megavolt charges and the explosive effects of its intense heat, lightning can blow apart trees or blast the bricks off buildings. It commonly electrocutes cattle seeking

shelter under trees in rainstorms; the current enters the ground through a tree's roots, then travels up the legs of the hapless creatures.

Most skyscrapers, broadcasting towers, bridges and industrial plants have lightning rods. Devised by Benjamin Franklin in the 1750s, the lightning rod is designed to "catch" a bolt and direct its current safely to the ground. Even the steel reinforcing rods inside the concrete CN Tower - which is struck repeatedly during the summer thunderstorm season - are thoroughly grounded. Steel power pylons, obvious lightning attractors, are grounded as well, and their high-voltage lines are protected by lightning arrestors, devices that sense the surges lightning produces, shut down the system, then automatically restart it seconds later. They keep your power on during an electrical storm - and leave your digital clocks flashing.

But some things can't be protected. Lightning ignites 4,000 forest fires on average each year in Canada, burning more than two million hectares (an area larger than Lake Ontario). Modern forestry recognizes fire as an important player in the forest cycle, but it remains the enemy in certain stands and near communities. Thus the forest ranger, once a sentinel in a tall tower in the woods, then in a patrol aircraft, is now also stationed in an office scanning computer screens for news from electronic lightning-detection systems.

Two years ago, Canada was outfitted with such a system, by which unmanned sensors can pinpoint ground-striking lightning bolts to within a few hundred metres. There are 81 stations - with sensing antennas, GPS receivers and satellite dishes - distributed from coast to coast. A lightning flash almost anywhere in forested Canada is detected by at least 4 and as many as 10 stations, and its strength, polarity and time to the millisecond are recorded.

"They pick up the electromagnetic pulse that lightning produces," says Garry Pearson, who manages the $9.5 million Canadian Lightning Detection Network from an Environment Canada office in Halifax. "It's like your radio crackling when there's lightning nearby."

The sensors transmit the pulses to Global Atmospherics Inc. in Tucson, Ariz., where computers locate the lightning by triangulation and send the information back to Environment Canada offices, all in a few seconds. Similar lightning-detection networks operate in 40 countries - covering much of the forested world.

"We get the information as dots on a screen," says Pearson, "usually overlaid with satellite pictures and other information. It gets kind of exciting sometimes - or at least exciting for meteorologists - when there's a lot going on and we can see how things are developing. Formerly, even with radar and satellites, we couldn't always be sure there was a storm in progress. Now if we see there's lightning, that confirms it."

So the lightning reports are of immediate value in weather forecasting and, as all the information is saved, of lasting value as a source of data.

"We archive everything," says Pearson, "the lats and longs of the strikes, amperage, time to the millisecond. It builds up a climatology of lightning, a history of the more vulnerable places."

That information is vital to airlines plotting routes, power companies planning power lines, golf-course designers, construction firms - and insurance companies, which use the archives to verify claims of lightning damage. In a third of the lightning-damage claims that Global Atmospherics was asked to verify for insurance investigators last year, there had been no lightning.

Forestry departments are the major clients of lightning-detection systems, both the new cross-Canada network and various provincial counterparts. They all do the same thing: watch for lightning strikes in parched or otherwise high-risk regions and, allowing for smouldering time, send up an aircraft in a day or two to look for smoke.

"Give credit to Environment Canada," says Peter Konopelny, a super-visor with Manitoba's forest-fire program. "For accuracy, reliability and maintenance, the new national system is far better than what we had before. And, bottom line, our ability to detect forest fires is greatly improved."

In the months after being struck, Christine Fram found herself changed, not totally impaired but still facing "a whole bunch of little things" she hadn't experienced before - problems with memory, mental quickness and fatigue.

"Sometimes I know I seem dense," she says. "I see an apple in a store, and I can't think of what it's called. And sometimes when somebody says something to me, it takes me longer to figure out what was said. I have trouble with hearing and seeing too, not with the senses themselves but with the brain's interpretation. I can't distinguish conversation from background noise or judge distances so well."

Sorting out the order of things can also be a problem. "I follow a checklist when I get up and get dressed in the morning," she says. "I lost the ability to multi-task. Things are very much one at a time now."

These are all classic TBI (traumatic brain injury) effects, she says, similar to those from a stroke. "I look the same, but my life has been rewritten. My husband has been wonderful. We were planning on having children. Now I don't know."

When lightning strikes a person, the current passes over the skin, which may or may not burn, or along the nervous system throughout the body, which can cause cardiac arrest, blindness, coma, memory loss, depression and other emotional problems. Sometimes the damage is light; sometimes it's severe. Sometimes people recover; sometimes they don't. The main cause of death is cardiac arrest.

Lightning injuries are quite different from other high-voltage electrical traumas. Yet when caring for lightning victims, most physicians make similar assumptions, says Mary Ann Cooper, director of the Lightning Injury Research Program at the University of Illinois.

"Many patients, particularly those without external signs of injury, have been told by medical professionals that they have 'internal burns,'" says Cooper. "This is both a misnomer and an oversimplification of the cellular, vascular or biochemical damage that may have occurred."
The diagnosis and treatment of lightning victims is a complex challenge. Little is known about their injuries from the standpoints of electrical engineering, atmospheric physics and physiology, says Cooper. "Therapy specific to lightning injury has yet to be agreed on and needs development."

Cumulonimbus clouds, the massive and menacing ones that bring us heavy rains, hailstones, high winds and tornadoes, are the main source of lightning. They become electrically charged, apparently through collisions between hailstones and ice crystals, and the charged particles separate, leaving the top of the cloud positively charged and the bottom negative.

When the buildup of positive and negative areas becomes too great, a þash of electric current - and we're talking millions of volts here - jumps across the gap, usually within the cloud and causing that diffused illumination known as heat lightning.

About a third of the time, the current leaps between cloud and ground. Here, the cloud sends out a pulsating, charged channel, called a stepped leader, that travels the 5 or 10 or more kilometres to the ground in a fraction of a second. With each pulse, a portion of the cloud's negative charge is transferred downward and deposited along the channel of ionized air. This channel measures up to 10 metres in diameter at the outset but, once the connection to the ground is made, constricts to the thickness of your little finger.

Meanwhile at ground level, the approaching leader coaxes a positive discharge from any available tall object: a building, church spire, flagpole, tree, even a person (whose hair will stand on end). Roughly 100 metres up, the descending leader connects with the ascending discharge, the circuit is complete, and the charge in the ionized channel drains to the ground in a blinding þash. Often, the process is repeated within a single bolt, giving lightning its flickering appearance.

The surge of current heats the air in the channel astronomically, expanding it at supersonic speed and generating tremendously loud sound waves - thunder. Close up, it's a decided Crack! But as the sound waves are absorbed and buffeted between clouds and ground, it becomes a low rumbling.
In all, it's the wildest son et lumière show on Earth, always dramatic to witness, best to stay out of its path.

Christine Fram used to be a talkative person, fond of conversation, but she now finds that her words travel faster to her hands than through her mouth. "I rely heavily on a computer these days," she says. She has created an Internet site (http://www3.telus.net/lightningsurvivor) devoted to her experience.

"It drives my life right now," she says. "When I was struck, there was very little information. I was providing it to the doctor. If people find the site helpful, that's all I want."

Judging from the stories posted on Fram's and a handful of other websites, including that of a support group called Lightning Strike and Electric Shock Survivors International (www.mindspring.com/~lightningstrike), the web offers a vital outlet for lightning's victims. Some stories are ironic, others are grim accounts of injury, disability and despair.

"It's a life-changing experience," says Fram. "You have to start over again."

Contributing editor Dane Lanken lives near Alexandria, Ont. To comment on this article, e-mail lanken@canadiangeographic.ca.

Back to lightning home page

A SPECIAL DEDICATION TO MY BEST FRIEND

**As well as Lightning Strike survivors, this page is now dedicated to my best friend Keith Chambless.
He passed away May 23, 2000 from injuries he sustained in a motorcycle accident May 2, 2000.**

**Keith provided so much friendship, comfort, support, encouragement, and laughter throughout everything that life had put on my plate especially my lightning strike.
Keith, I miss you and will remember you always.**

The Lightning Survivors Resources On the Web is dedicated all survivors of a lightning strike. It is also dedicated to those who didn't survive. I hope through this page I can honor them.

SPECIAL THANKS TO:

My husband Rob, Without you, my journey of recovery the past 3 1/2 years would have been painfully lonely. I love you!

My friends and family who support me, love me, and try very hard to understand the depth of my injuries.

Dr. Mary Ann Cooper - University of Illinois at Chicago. She was my first and most significant resource. Her studies of lightning injury and its effects on the human body provided my health care providers with invaluable information.

Dr. Tanya Wulff, Her patience, knowledge of brain injury, her commitment to my emotional health and recovery has helped to guide everyone in an appropriate course of action as I re-established the salvageable parts of my life that I could and came to know and accept the new me, and the new life I've created.

Dr. HT Peters, My wonderful GP

Julie, Mary and all the staff at O/T Consulting, Yvette Hankin and Moira McNicholes at the Worker's Compensation Board.
These compasionate, dedicated people have patiently and gently guided my rehabilitation program forward. Their hard work allowed me to make signifigant improvements in my abilities. They gave me useful skills to compensate for the impairments that couldn't be improved on, thus giving me a better quality of life. I am very grateful.

Last but not least:

Sandy Corbett of Western Occupational Rehabilitation Consultants & Alex Jackson at BC's Worker's Compensation Board. As I am no longer employable due to my brain injury they still provide me with the resources to enhance my life and give it meaning.
My involvement with helping other Lightning Strike Survivors has given me back that special drive that we all need to feel our lives are worthwhile.

Remember, If you can help just one person in your lifetime, your life has not been wasted.

To all those who's career's are devoted to helping and healing, I salute you!

Back To Main Page

Dreambook for Lightning Strike Survivors Resources on the Web

Welcome to my nifty Dreambook, a free guestbook service from New Dream Network and the DreamHost!

If you have a minute, please add your entry to those below by signing my Dreambook!

Comments: Online Dating Service, FREE Personals, and Matchmaking website for American Singles and International Singles, Beautiful and Romantic Single Women and Single Men. Join FREE now and find a date today!

Name: Online Dating Service, Free Personals, and Matchmaking for American Singles

E-mail: links@romanticsingles.com

Homepage: http://www.romanticsingles.com

Saturday, August 28th 2004 - 03:53:12 PM

Comments: Hello,

I have a friend who was struck by lightning about two years ago. We both live in Kansas. We are wondering how to go about finding support groups and info. about doctors who specialize in treating shock victims. The internet doesn't seem to provide a great deal.

Name: Jeffrey Farrar

E-mail: jeffrey.farrar@washburn.edu

Wednesday, August 25th 2004 - 11:26:31 AM

Comments: Congratulations on finally setting up your site. I am sure the website will become a internet legend

Name: tramadol

E-mail: azaddin6791@work.com

Homepage: http://www.tramadol90.net/

Monday, August 23rd 2004 - 10:16:02 AM

Comments: I was recently struck by lightning while working on an offshore platform for an oil company. Everything turned out alright, I just wanted to know more about what I was experiencing. My main concern was to learn more about the myth of the chances of being struck again. Are my chances just the same as anyone else, or am I more prone to being struck again. Thanks for the page. It was very helpful.

Name: Jeremy Sokol

E-mail: jsokol1212@hotmail.com

Friday, August 20th 2004 - 08:50:18 PM

Comments: i liked the page. it really helped me understand the dangers of being hit by lightning. i never use anythung metal anymore. you may have savedmy life. thankyou

Name: I.P Freely

E-mail: imathome@hotmail.com

Homepage: http://thebladder.com

Tuesday, August 10th 2004 - 11:58:55 PM

Comments: Lovely to see such a wonderful site. Thank you

Name: online casino

E-mail: grey_goose4145@aol.com

Homepage: http://www.onlinecasino-4u.com/

Friday, July 30th 2004 - 05:59:05 PM

Comments: Hello, On July 3, 2004, I was seeing shelter under a wooden gazebo, when it began to rain, in Myrtle Beach, S.C., while visiting a state park. I had only heard a distant rolling thunder, and had seen no lightning. When the rain stopped after only a few minutes, we stood up to leave, when I felt an immediate "grip" of electricity, which seemed to hold me upright, for a second or two, an intense heat in my body, from my chest down, accompanied by a tremendous explosion. I found myself on the floor, in an awkward, sitting position, having been thrown violently, several feet, with no sensation, or movement from the waist down. The lightning entered my body in my upper abdomen, leaving a scorched hole in my shirt, and exited through the side of my right foot, leaving a deep burn on my foot which has still not healed. Within several minutes, my legs began to swell, and turn dark blue as there were no pulses, and even though I could not feel or move them...the pain was excruiating. It was 4 hours before I slowly began to have any sensation, and several days before I even felt like my legs were a part of the rest of me. I could go on and on about the difficulties since leaving the hospital, but the list seems to grow each day, rather than getting smaller. I'm beginning to feel like a circus freak....everyone wants all the gory details, and still have constant pain, the exit wound is slow to heal, I have thes unnerving "jolts" in my legs, and although I know I should be grateful to be alive, I find that I can't sleep, or want so much to sleep in the middle of the day, feel depressed often, and even seem to cry for no reason. Once, I was sitting, talking with a client, and suddenly began to feel this intense heat, and "jolts" in my legs again, and could even smell the unmistakable odor of singed hair and skin....and had to stop my conversation, it was so uncomfortable. It seems I can't regulate my body temperature, and often, break out into a sweat for no reason. I would like very much to hear from anyone who may have had any similar experience. Does it get any better???? How long? Thank You

Name: Bill

E-mail: coastal36@aol.com

Wednesday, July 28th 2004 - 05:30:25 PM

Comments: very interesting. my aunt was killed in lightning b4 i was borne (or so my mom has told me).

Name: darianmo@frxglobal.com

E-mail: darianmo@frxglobal.com

Wednesday, July 28th 2004 - 12:59:35 PM

Comments: very interesting. my aunt was killed in lightning b4 i was borne (or so my mom has told me).

Name: darianmo@frxglobal.com

E-mail: darianmo@frxglobal.com

Wednesday, July 28th 2004 - 12:59:03 PM

Sunday, July 25th 2004 - 10:00:52 AM

Comments: hi, i`m sarah from dorset, england, uk. i was struck by lightning in july 1995, still have numbness and tingling in hands and feet, i also have a perminant blind spot in my right eye, still don`t like storms, i hide under the stairs. at the time of the incident lightning had effected my voice box, as i had a mans voice for about 5 mins.
it would be great to hear from other people who have been hit, great site, keep up the good work.

Name: sarah gossling

E-mail: kev@gossling7816.fsnet.co.uk

Saturday, July 17th 2004 - 08:54:44 AM

Comments: I friend gave me this URL. I got struck for the 2nd time on July 10, 2004. First time was twelve years ago when I was living in NE Alabama.

Name: Mark Cobbeldick

E-mail: kb4cvn@yahoo.com

Wednesday, July 14th 2004 - 10:18:22 AM

Comments: Hi! Myname is Erin and I work at a waterpark in Texas. Two days ago lightning struck the ride i was working and i guess the secondary shocks hit the water...where my hand was. I felt a jolt and saw a flash where my hand was. I was extremly scared and now i am just trying to reasearch lightning so that it doesnt happen to me again. This is a great site! Good work!

Name: Erin

E-mail: bbgurl6789@yahoo.com

Thursday, July 8th 2004 - 06:58:27 AM

Comments: Very nice site. Good work!!
Please visit our sites
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Viagra Online Cheap Levitra Cheap Viagra Weight Loss Buy Cialis

Name: Bill

E-mail: bill1698@hotmail.com

Homepage: http://www.starpills.com

Monday, July 5th 2004 - 09:11:07 AM

Comments: I was hit by lighting three years ago and now I am DEAF.

Name: vickie Bueno

E-mail: vickiebueno@yahoo.com

Wednesday, June 30th 2004 - 07:02:36 AM

Comments: Great Job..cool site

Name: Annie

E-mail: skejbh12@msn.com

Homepage: http://www.cialis-buy.com

Tuesday, June 29th 2004 - 04:24:53 PM

Comments: Anti-Depressants Antidepressants Generic Viagra Hydrocodone Vicodin Generic Viagra Online Pharmacy Generic Vicodin Online Degree Online Education Online Online Education College Fashion Design School Interior Design School Graphic Design School
Computer Animation Information Technology Education Cooking School Culinary Master Degree Bachelor Degree Medical School Online Business School Degree MBA Degree Online Technical School Institute Generic Viagra online pharmacy drugstore online online medications Paralegal Education
Phentermine Levitra Consolidate Debt Debt Consolidation Generic Viagra Dental insurance Cheap Viagra Human Growth Hormone Hgh Adipex Diet Patch Phentermine Tramadol Propecia Ultram Vitamins Supplements Online drug store Overseas Pharmacy
Debt Management

People posting to these types of boards are ruining SEO (Search Engine Optimization) as we know it. If the owner of this site is interested in curbing this problem, please obtain another script that does not allow HTML or that requires verification and you will stop the endless advertizing on this board. Otherwise people will continue to do this indefinitely. Or perhaps you don't mind?

Name: Generic Viagra

E-mail: hjgdfsaa@hjhjh.com

Homepage: http://www.buy-generic-viagra-sildenafil-citrate.com

Monday, June 28th 2004 - 09:47:15 AM

Comments: Hi

I found your guest book while searching on the internet for information to help another lightning strike survivor. I do have a question for you. Do you have residual pain from the strike, did you at anytime and how was it treated. Do you know of any other places I might find out more information about the pain experienced. You'll never know how much this means to me if you can help me out. thank you for being on the internet. THANK YOU THANK YOU THANK YOU

Name: Michele Spencer

E-mail: kspencer@comcast.net

Saturday, June 26th 2004 - 06:20:16 PM

Comments: Very nice site. Good work!!
Please visit our sites
***

Viagra Online Cheap Levitra Cheap Viagra Weight Loss Buy Cialis

Name: Bill

E-mail: bill1698@hotmail.com

Homepage: http://www.starpills.com

Wednesday, June 23rd 2004 - 12:32:37 AM

Comments: Hi there.
Thanks for so much information on your site, it's been a great help.

Name: Casper Rix

E-mail: datghost@ktb.co.uk

Tuesday, June 22nd 2004 - 12:01:24 PM

Comments: JUST SEEN YOUR STORY ON REALITY TV AND FOUND YOU WEBSITE GREAT SITE LOADS OF INFO. WELL DONE.

Name: S

Tuesday, June 22nd 2004 - 07:16:53 AM

Comments: Yesterday while sitting in the car in the driveway of a friend to wait out a terrible rain and thunderstorm, I think we were hit by lightning. We were parked in the drive under very tall trees, with an open area in the yard to our left.

As I was facing my friend looking to her on my left, we heard this terrible thunder and I saw just out the window the most awful, amazing sight. It was lightning for sure. I do not remember seeing a bolt, but a huge ball of light, rimmed with very white light then moving toward the center brilliant yellow and in the center the reddest hottest red flame like glow. It seemed that the sound and the vision came together or nearly together. We sat still for a long time after that and did not leave the site until we could hear no more thunder. The rain alackened.

When my friend arrived home her husband was furious that a part of the car's left bumper (metal) was deeply dented and the end part of the bumper was missing.

He was sure that she had hit a tree and pulled that part off. Although we did have to back up among some tall trees, neither of us hear or felt any impact. They did return to the site and did find the missing bumper.

Could lightning have hit the bumper?

Name: Bettie Davis

E-mail: bdavis_latx@myexcel.com

Homepage: http://www.excelir.com/grannyonthego

Sunday, June 20th 2004 - 06:32:11 AM

Comments: I am writing a story about lightning and lightning safety for a northcentral Pennsylvania (Lycoming County) newspaper. I would like to include interviews with lightning survivors who live in that area. If anyone is interested in talking about their experience, I would be happy to include them in my story.

Name: David Thompson

E-mail: dthompson@sungazette.com

Monday, June 14th 2004 - 08:26:05 AM

Comments: Thank you for creating this site. I have seen it linked to from many other areas. I found you from Google. You information and links helped me very much.

I was recently very close to a major strike, and suffered some ill effects. I am getting better, but it was comforting to know that a near-strike could cause my sudden symptoms the day after the strike occurred: extreme, deep fatigue, multiple muscle strains and spasms where I felt the shock wave hit, all-over pain, headaches, ringing in the ears, hypersensitivity in my fingertips, short-term memory loss, and loss of emotional responses, and sunburn-like burning skin all over the side of my body that faced the strike.

Name: M. Reed

E-mail: rochelimit_72@eudoramail.com

Saturday, June 12th 2004 - 09:07:35 PM

Comments: we were struck by lighting 02/02/02

Name: ami and nezzy

E-mail: nathan980@hotmail.com

Friday, June 11th 2004 - 02:54:04 AM

Comments: Hi, I stumbled onto your sight after searching on Google for data about ringing in the ears. The information you've presented is frightening, particularly the fact that so many people have been "struck" by lightning while inside the safety of a building. I, too, have adored thunderstorms from a young age, but will no longer be able to view with the same peaceful feeling. The knowledge you survivors share should be communicated loudly to all. Best wishes in all you do,

Name: Mari

Wednesday, June 9th 2004 - 08:55:48 AM

Comments: i was struck by lightning 5/31/04. tubing on river when storm rolled in. took shelter from hail under a tree. i think the tree was struck, unsure of details as this is very recent. told i had no pulse or breathing and heart was defibralated 5 times. have 3 days of no memory and partial memory after that. was hospitalized until 5pm on 6/2/04.

Name: gary blindert

E-mail: gblindert@hotmail.com

Sunday, June 6th 2004 - 06:54:17 AM

Comments: iLOST MY SON WHO WAS 12YRS OLD ON MAY 26TH 1995 HIS NAME IS JUSTON ALAN HILL

Name: JULIA HILL

E-mail: UGHLALALALA@AOL.COM

Monday, May 24th 2004 - 08:03:27 PM

Comments:

I was hit by lightning in June of 2003 things will never be the same!

Name: STEVE MATZKOW

E-mail: steve_matzkow@fws.gov

Thursday, May 20th 2004 - 01:51:36 PM

Comments:

I was hit by lightning in June of 2003 things will never be the same!

Name: STEVE MATZKOW

E-mail: steve_matzkow@fws.gov

Thursday, May 20th 2004 - 01:51:32 PM

Comments: I too have a strong fear of lightning. Although I'm told that I'm not going to get struck by lightning, and I shouldn't worry about it, I beg to differ. I have had a few very close encounters of seeing bolts of lightning strike the ground at a close ranges. I've never been struck however. But with today's trying times the odds might seem against everyone. I've heard some true scary stories that even though people were safe indoors, lightning had struck down and took a path through a person's house with the bolt zooming across the room. A Tip I had been taught by my science teacher is that you know your about to get struck by lightning if you feel a strong amount of static electricity and a tingly feeling on and around your body. For a few seconds later BAM! You know where lightning is gonna strike. But my biggest fear is where it's gonna strike next.

Name: John

E-mail: dinoboy38@netzero.com

Thursday, May 13th 2004 - 08:20:20 AM

Comments: I too have a strong fear of lightning. Although I'm told that I'm not going to get struck by lightning, and I shouldn't worry about it, I beg to differ. I have had a few very close encounters of seeing bolts of lightning strike the ground at a close ranges. I've never been struck however. But with today's trying times the odds might seem against everyone. I've heard some true scary stories that even though people were safe indoors, lightning had struck down and took a path through a person's house with the bolt zooming across the room. A Tip I had been taught by my science teacher is that you know your about to get struck by lightning if you feel a strong amount of static electricity and a tingly feeling on and around your body. For a few seconds later BAM! You know where lightning is gonna strike. But my biggest fear is where it's gonna strike next.

Name: John

E-mail: dinoboy38@netzero.com

Thursday, May 13th 2004 - 08:20:11 AM

Comments: I think wat u r doin here is a great thing. People that have been struck by lightning can really go somewhere where people won't be lookig at them strange. Keep up the good work my prayers r wit u. God bless

Name: Lesley Jones

E-mail: edwhitequeen_06@yahoo.com

Wednesday, May 5th 2004 - 06:39:53 AM

Comments:

Thanks for the site. I work for a television news station in San Antonio, and I was struck July 2nd, 2002 while shooting video of an approaching storm. The bolt struck about 10 feet behind me, it hit a fence, I think. It was so loud! I didn't even know I was struck until I got in the news unit and began driving away. My arms and stomach started aching and tingling at the same time, eventually paralyzing me, totally. The doctor later told me that getting struck by lightning the way I did is like wroking out for 100 hours straight! I can tell you that it took well over a month before I could work a full day because I was so tired all the time.

I've been thinking about my 'accident' a lot lately, because I've been noticing that I get sick easily, and I've had this headache that just won't go away. It's in the back of my head, almost as though it's a tension headache.

I'm trying to live my life without always thinking about the strike, but, lately it's been tough. Anyone have similar problems?

Name: Jimmy
E-mail: senastruck@yahoo.com

Wednesday, April 21st 2004 - 03:30:57 PM

Comments: Nice site you have! bookmarked it and hope you keep it up!
Cu Simone
Name: Simone
Homepage: http://www.01taxi.com/

Tuesday, April 20th 2004 - 11:18:46 PM

Comments: John feel free to contact me Love rhea
Name: rhea
E-mail: rhead@spymac.com

Monday, April 19th 2004 - 07:53:43 AM

Comments: Hi,
My name is John and I am an author doing resaerch for a fictional piece I'm working on. Truth is stranger than fiction they say and after visiting your site, I tend to agree. I have visited many sites, but yours, by far was the most informative. Thank you, and best wishes on your continued recovery.
Name: John M. Barrington
E-mail: JMBARRINGTON@AOL.COM

Wednesday, April 14th 2004 - 09:56:35 PM

Comments: Phentermine
Diet Pills
http://www.pillslim.com

Name: Phentermine
E-mail: phentermine@yahoo.com
Homepage: http://www.pillslim.com

Wednesday, April 7th 2004 - 10:24:47 PM

Comments: Levitra
http://www.levitracart.com
Name: levitra
E-mail: abc@hotmail.com
Homepage: http://www.levitracart.com

Thursday, April 1st 2004 - 08:56:44 PM

Comments: Saw your documentary in Bangkok Thailand on March 31,2004. Searched with Google using key word "Lightning Victim vancouver" and found your page. Never thought that lightning can injure person inside a metal building before.
Name: VIVATVONG V. VADAKAN
E-mail: vivatvng@pointasia.com
Homepage: http://www.pointasia.com

Tuesday, March 30th 2004 - 10:44:32 AM

Comments: Very nice site. Best regards. Steffen
Name: Steffen Riedel
E-mail: steff_riedel@t-online.de
Homepage: http://sport-artikel-shop.pecunianum.de

Thursday, March 25th 2004 - 03:37:16 AM

Comments: Hi,
My name is jim McGowan. I'm an author and am presently working on a book about individuals who, after suffering a lightning strike, began experiencing psychic awareness (clairvoyance, psychokinesis, precognition, out-of-the-body experience, and others). I would like to interview individuals who've had any of these experiences. Do you know of any, or is there an organizsation of such individuals? Any assistance you can give me will be appreciated.
Name: Jim McGowan

E-mail: jimmymac13@peoplepc.com

Wednesday, March 24th 2004 - 07:32:43 PM

Comments: Hi everyone

A big thank you for this wonderful site, it has helped me immensely.

If you have time on your hands, I would sure appreciate you visiting my site also.

Thanks

Mary

Name: Phentermine

E-mail: meridia@chic-phentermine.com

Homepage: http://www.chic-phentermine.com/

Wednesday, March 24th 2004 - 03:25:35 PM

Comments: Great site guys!

Rex
http://www.phentermine-ms.com

Name: Rex

E-mail: rex@phentermine-ms.com

Homepage: http://www.phentermine-ms.com

Wednesday, March 24th 2004 - 06:10:47 AM

Comments: Great site guys!

Rex
http://www.phentermine-ms.com

Name: Rex

E-mail: rex@phentermine-ms.com

Homepage: http://www.phentermine-ms.com

Tuesday, March 23rd 2004 - 03:04:15 PM

Comments: hi my name is kenny munro and i was struck by lightning when i was panning for gold in devor,california..

Name: kenny munro

E-mail: kennymunro@hotmail.com

Friday, March 19th 2004 - 09:13:36 AM

Comments: hi my name is kenny munro and i was struck by lightning when i was panning for gold in devor,california..

Name: kenny munro

E-mail: kennymunro@hotmail.com

Friday, March 19th 2004 - 09:13:27 AM

Comments:

tramadol
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ultram
wellbutrin
phentermine
meridia
cialis
propecia
tramadol hydrochloride
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Online Pharmacy

didrex
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gaming
online gambling
betting online
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Name: Randy Evans
E-mail: Randys@att.net

Tuesday, March 16th 2004 - 05:58:52 AM

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Name: James Spitzer
E-mail: Spitaer700@yahoo.com

Tuesday, March 16th 2004 - 05:57:09 AM

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Name: Gordon S.

E-mail: Sgordon@comcast.net

Tuesday, March 16th 2004 - 05:54:28 AM

Dreambook - Lightning Strike Survivors Resources on the Web

Please sign my Dreambook for Lightning Strike Survivors Resources on the Web.

Comments

Name

E-mail

Homepage http://

Sign the Book

[View Guestbook | Lightning Strike Survivors Resources on the Web]

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