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Why a Greenhouse to grow Raspberries?

There are some specific advantages to growing raspberries in a greenhouse over field grown berry's. First, raspberries have a relatively low chilling requirement for over-wintering, about 45 days below 45°F. Then the plants can be brought into the greenhouse from the cold to bring them out of dormancy early. They also prefer cool growing temperatures (55°F to 70°F), so the cost of heating the greenhouse is less than it would be for other crops. Growers in areas that winter begins early, have the added advantage of satisfying the chilling requirements (over-wintering) earlier. Those in warmer claimants may find it beneficial to use a separate chilling room to speed up the process.

Also in most locations they don't need supplemental lighting to produce high yields. One study did a test using both supplemental light and without. The plants with supplemental lighting began to flower 2 weeks earlier, but the total yield over the season (about 4 months) was just about even for both tests. Another advantage to growing raspberries in a greenhouse is that greenhouse plants are not subject to the foliage and berries getting wet by rain or dew. Wet raspberries are very susceptible to rotting, and damaged berries are useless and won't sell. So just by using a greenhouse to grow them in, you will significantly increase the profitable/usable yield of your plants.

Greenhouse raspberry plants are typically watered via-drip system whether they are grown hydoponically or not. But growing them hydroponically

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significantly reduces the possibility of soil born diseases being introduced to the root systems, provided they were certified virus indexed plants to start with, resulting in healthier plants. Because the fruit has been kept dry (out of the rain and morning dew), the storage and shelf life of ripe raspberries (under refrigeration) is greatly increased, thus stays fresher longer for the consumer. In addition, many of the insects/pests that can be a problem during the summer months are not active during the off season in the cold winter months.

Growing your hydroponic Raspberries

Even with all the requirements that raspberry plants have (size, trellising, chilling etc.), they have been grown in practically all types of hydroponic growing systems, even NFT, DWC and Aeroponic. Some growers may even use grow bags full of growing medium, and simply cut a slit in the bag to insert the plants in and use a non recovery drip irrigation system. A well fed raspberry plant doesn't necessarily have a large root system for it's size, it can be even smaller than that of a mature tomato plant, but still last for years. As always hydroponic growing medium is mostly a personal choice, however it's important to make sure the growing medium drains well and doesn't remain to wet. Typical growing mediums used for raspberries by most growers include: sand, vermiculite, peat and perlite, either by themselves, in equal parts, or in just about any combination of them.

Probably the most common type of hydroponic system to grow raspberries in is a drip system. Either as a recovery ,or non-recovery system (also called run to waste). Non-recovery simply means that the nutrient solution is not returned back to a central reservoir, but is allowed to run off. Depending on the size and age of the plant, growers use buckets starting from 3 gallons and transplanting into larger buckets up to 7 gallons as they get bigger. All the plants energy is stored in the roots, so make sure to take care to do as little damage as possible to them when transplanting if doing so. Also make sure not to let the roots dry out before, during, or after transplanting.

To determine how many raspberry plants can fit in your greenhouse, just calculate how many plants you can fit in a row, spacing them two feet apart. For floricane-fruiting plants, determine how many rows you can have with about 5 1/2 to 6 feet between rows, remembering to leave at least 3 feet between the end rows and the greenhouse walls (for harvesting etc.). Rows for primocane-fruiting varieties can be spaced closer, at about four feet apart. Closer spacing can result in pour air circulation that can lead to disease.

Optimum Growing Conditions

Growing Raspberry plants using hydroponics gives the grower maximum control of the plants nutrition, and naturally quality. According to one study raspberries grow better with a higher proportion of N relative to P and K. Another study used the same nutrient formula they used for strawberries with very good results. Raspberry's are a crop that can tolerate low light levels, and even lots of cloudy days. So even though supplemental lighting may increase a yield somewhat, the cost of running

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the lights may out-way any increase in yield from of using them. Not to mention, considering the add expense of installing them if they were specifically installed for the raspberry crops only.

Raspberries thrive in cool climates, with the optimal daytime temperatures around 72°F, and nighttime temps around 55°F to 60°F. But like any plant, they can tolerate and adapt to higher or lower temps, as well as fluctuations.

The optimum humidity range is between 65% -75%. Humidity levels above 90% will encourage fruit molding and pour pollination. Humidity levels below 65% will encourage mite infestations as well as pour pollination also.

A supporting trellis system is an important part of good raspberry production. As the fruiting laterals become heavily weighted down with berry's and foliage, they will tend to bend over and break from the weight. Once the growing season is over all the leaves can be trimmed off, and the old canes can be pruned off as well. Pruning and trellising will affect plant growth, fruit quality and quantity, as well as size. So you should get to know your canes.

Pollinating Raspberry's

Unfortunately pollination is probably the biggest drawback to greenhouse and off season production of raspberries for most growers. Unlike some crops that can be pollinated by shaking the plants, air currents and a just a good breeze, raspberries need to be pollinated by insects. More than 30 flowers can be produced by one single fruiting lateral, and most buds that reach 2mm continue to develop, set fruit and mature. Insect pollination is essential for good fruit set. Hand pollination is to labor intensive, not to mention to hard to keep track of which flowers were pollinated to be cost effective.

For summertime crops, some greenhouses may be built with openings that allows outside bees to come inside to pollinate. But depending on the size of operation that may still be inadequate to pollinate all the flowers, although a beehive can be brought into the greenhouse for adequate pollination. For the home grower, planting flowering plants around openings in the greenhouse will attract bees inside to pollinate the raspberries. For off-season (wintertime) crops, most bee hives are inactive, especially in northern areas. Even inside a greenhouse it may not be warm enough for bees to be active enough, even above the optimal temp for raspberries of 72°F.

Bumblebees are very good pollinators, and remain active in much cooler temperatures than bees. They are also quite docile and wont sting unless provoked. But bumblebee hives don't have a long life-span like bees do. Bumblebee hives will last about 10 to 12 weeks or so. Depending on the

variety of raspberry and if your staggering the production cycle or not, you may need more than one bumblebee hive to pollinate your crops. The stigmas of the flowers may only remain receptive to pollination for about 6 days or so, so it's important to have your pollinators ready when the flowers begin to open. For growers serious about raspberry production, it may be well worth their while to learn to raise bumblebees themselves, especially for year round production.

Along with bees and bumblebees as pollinators, Blue Bottle Fly's are a recent option for pollination. Like bumblebees the blue bottle fly's will remain active in cooler temperatures than bees will. Blue bottle fly's are also suited for use in greenhouses. They don't like to stay in one place, and tend to fly off. But work well in confined spaces like a greenhouse environments. It's important to remember bees, bumblebees and fly's are all insects also, the use of pesticides will have a negative effect on them as well. Most growers are learning that the use of beneficial insects for pest control will still allow them to be able to control the pest populations, as well as not effect the other beneficial insects like the important pollinating insects.

Growing Hydroponic Raspberries, part 1

Useful links
Greenhouse Raspberry production guide (Cornell University, pdf)
High Tunnel Raspberries and Blackberries (Cornell University, pdf)
Greenhouse Raspberry Production for Winter Sales
Pruning Raspberries, Blackberries and Gooseberries
OFF-SEASON PRODUCTION OF STRAWBERRIES AND RASPBERRIES
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Growing Hydroponic Raspberries, part 1

Typically raspberries are not considered good plants to grow hydroponically by growers because they are long term plants that depending on type of raspberry plant, may not produce any fruit in the first year. Because there are no real large producers of out of season raspberry's in the USA, most of them are imported from Mexico and Chile during the off season. That results in pour quality as well as higher prices because of the long distance they have to travel get to market. Even with the high prices and low quality of off season raspberry's, people are still apparently willing to spend their money on them. And for those people who like fresh raspberries, growing their own can be very rewarding.

Raspberry's are a high value crop that can sell for between \$3 and \$6 for a 1/2 pint during the off season, and typically sell for around \$3 or more when they are in season. Each plant can produce 8 to 11 1/2 pints of berry's in one season (about 4 months) for second year plants, and 3 or 4 year old plants can produce as much as 20 1′/2 pints or more in a season. Let say they sell at \$3.50 for a 1/2 pint, and each plant yields 11, 1/2 pints, that's a total of \$38.50 (11, 1/2 pints at \$4.50= \$49.50) of product from each plant. So there's a lot of potential for profit, especially when rotating plants to provide for both in and out of season berry's. Even so very little information exists on hydroponically grow off season raspberry's. Yet because they are a highly perishable product, there is always a demand for fresh locally grown high-quality raspberry's.

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Types of Raspberries

There are two basic types of raspberries plants (called canes). **Primocane-fruiting** (Fall-Bearing, and/or everbearing) and **Floricane-fruiting** (Summer-bearing). **Primocane-fruiting**, produces fruits at the top of the first year canes. If allowed to over-winter, these same canes will produce fruit again on the lower portions of the canes in early summer of the second year. However the second year fruit of the primocanes is said to be less quality than the first year fruit. Some growers will sacrifice the second-year crop in favor of the smaller but higher quality late fall primocane crops by pruning the canes to the ground, at either the end of the first years harvest or in early spring of the next year before they begin to grow again. Then new canes will continue to grow and fruit each year in late summer.

Floricane-fruiting (only produce fruit from buds on second-year canes), and unlike primocane-fruiting raspberries, these canes must stay intact through the winter and into the following growing season to fruit. Also, during second-year of floricane-fruiting raspberry plants, while the canes are flowering and fruiting new first-year canes are growing (also called primocanes because these are the first year canes). These will produce fruit in the fallowing second year. At the end of the harvest year the second year canes (floricanes) should be cut to make room for the new primocanes that will fruit the fallowing year. If not they will just die and not produce fruit anyway, taking energy away from the fruiting canes.

Advantages and Disadvantages
Primocane-fruiting Advantages

- long harvest season from the same plant
- less labor moving plants in and out of the greenhouse because of the long season
- higher density of plants can be placed in the same space
- only a simple trellis is required for support

Primocane-fruiting Disadvantages

- mites and other pests can build up during the longer harvest season
- bees must be active thought the long season for pollination
- Primocane plant yields are lower than floricane

Floricane-fruiting Advantages

- superior flavor and fruit size than primocane
- shorter harvest season, but with higher yields
- easy to schedule plant rotations for production cycles
- bees have a shorter season they need to be active
- pests easier to control because of shorter growing season

Floricane-fruiting Disadvantages

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larger plants so they take up more space
- plants require more trellising support than primocane
- plant requires more labor in manipulation of the canes
- it may be two years before the full potential yields are realized
- accumulation from the chilling is required to come out of dormancy

Raspberry cultivars

For some reason not all raspberry cultivars (variety of a plant) produce well in the greenhouse environment. Some of the varieties that have shown to do well in the greenhouse include: (primocane varieties) Caroline, Josephine, Autumn Bliss, Autumn Britten, (Floricane varieties) Tulameen, Chilliwack, Cascade Delight and Encore. The Tulameen variety seems to be a particular favorite for it's large size as well as it's flavor, and also seems to be particularly resistant to insects and disease.

Growers that want to grow raspberries for profit will want to obtain high quality virus indexed plants from a reputable source. Preferably from a nursery that sells certified virus indexed stock. Certified virus indexed raspberry stock is propagated from plants that have never been exposed to the outdoor environment. They are grown under very strict conditions in order to be free of pests and viruses, including soil born pests and pathogens. Field grown plants can be used, but are much more likely to introduce pests and disease into the greenhouse that can affect the entire crop. Also virus indexed raspberry plants generally grow more vigorously, as well as be more productive and even tend to live longer.

Growing Hydroponic Raspberries, part 2

Useful Links

How to Grow Raspberries (video)
Different Varieties of Raspberries, Part 1 (video)
Different Varieties of Raspberries, Part 2 (video)

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Easy to Build Hydroponic System

One of the easiest hydroponic systems to build is commonly called a DWC (deep water culture) system. Although typically called a DWC system, it's usually really a combination of hydroponic systems. A true DWC system is nothing more than a water culture system, with a deeper reservoir instead of a shallow one. Depending on how it's built, most DWC systems combine a water culture system with one or more of these, drip, aeroponics and/or flood and drain systems. The easiest way to construct one is using a five gallon bucket with a lid, and a regular plastic pot. Cutting a hole in the bucket lid for the plastic pot to sit in without falling through.

The nutrient solution is placed inside the bucket where there is usually an air stone (connected to a air pump) is also placed. The air stone provides oxygen to the roots, and helps them to keep from suffocating in the water. Then the lid (with the pot) is set on top of the five gallon bucket. From there you have the basic DWC hydroponics system design. The key to the DWC system working is that the plants root system (either part or all of them) be submerged in the nutrient solution. From there you can make many variations, like if you wanted to recirculate the nutrient solution, and weather you wanted to recirculate it using a drip system, misters (aeroponic), or flood and drain. There are just to many variations to cover them all, but I will try to cover the most common ones.

Basic system

With no recirculating nutrient solution this would be the most basic, inexpensive and easiest. Without using a recirculating system the water level is very important, because the roots that are hanging in air (inside the

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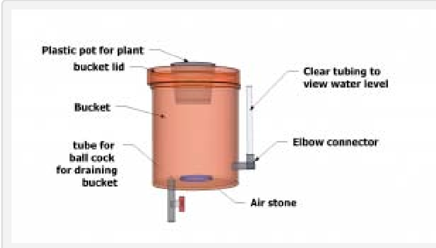
bucket) are likely to dry out. Also the roots that are in the growing medium (in the pot) wont get any moisture and dry out. So you will want the water level to be just above the bottom of the pot with the plants in it, that will allow the growing medium to wick up the nutrient solution, and keep the hanging roots wet.



Even though it's a basic system, there are a couple of things that will make it easier to use, and grow your plants. First is, you will want a way to drain the nutrient solution in order to make nutrient changes easier. The easiest way to do this is by simply just securely placing an end cap (or plug) on the drain tube that can be removed to drain the bucket/s. Another easy way is by installing a plastic or PVC "ball cock valve" at the bottom of the buckets.

Simply opening the valve will drain the buckets, then the new solution can be poured in from the top, right on the growing medium without even opening the lid. The next thing is you'll want to be able to check the water level easily. A simple elbow connector installed in the side of the buckets with clear vinyl tubing running all the way up to the top of the bucket will make it easy to see the water level inside the bucket. Just make sure it's covered when your not checking it to prevent algae growth in the clear tube.

The most common DWC/drip system

The most common DWC setup is probably the combination drip system, especially when using 2 or more buckets at the same time. Again there many variations on this type of setup you can do. But you wont need the clear tubing on the outside of the bucket for viewing the water level. You can set the water level by the placement of a overflow tube. The height of the overflow tube will keep the water level constant. Each time the drip system waters the plants, it drips down into the bucket filling it to the point of the overflow tube. The overflow tube then drains back to the nutrient reservoir, to be pumped back through the drip system again.

Because the water is recirculating between the buckets and a reservoir, the drain tube with the ball cock valve to drain the bucket with may not be needed. You will be able to just change the nutrient solution that's in the reservoir. There will still be the nutrient solution in the buckets, but as the new nutrient solution circulates through the system, it will mix with the old nutrient solution. So whether you want a drain on each bucket depends on weather you want to be able to get as much of the old nutrient solution out as you can when doing a nutrient change.

DWC/flood and drain system

The DWC/flood and drain system is fairly simple also, and as always can have many variations as well. The only real difference is how the water is pumped to the buckets. Instead of dripping down from above, the nutrient solution is pumped into the buckets from below the plants, through the water inlet tube. Then when the pump shuts off, the water begins to drain back down through the pump, and through the same inlet tube it was pumped up in.

DWC/aeroponic system

The DWC/aeroponic system is very similar to the DWC/drip system setup. Again the only real difference is the nutrient delivery system. Where the drip system drips down through the growing medium into the buckets, the aeroponic variation sprays the roots from inside the buckets with misters. The overflow tube would need to be low enough to allow the misters to spray the roots. But the water level in the buckets doesn't need to be real high anyway, because the misters will keep the hanging roots moist and from drying out.

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But you do want it high enough to keep a good amount of water at the bottom of the buckets.

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Aquaponics or Hydroponics

Aquaponics, also known as the integration of hydroponics with aqua culture, is gaining increased attention as a bio-integrated food production system. Hydroponics and aquaponics are close and often considered the same, but there are some distinct differences. With aquaponics, fish and plants are grown together in one integrated living soil-less ecosystem. The biggest difference is the nutrient source for the plants. With Hydroponics the nutrients are provided by refined chemical salts. With aquaponics, fish waste from living fish provides the food source for the plants, and the plants and plant beds can provide a natural filter for the water the fish live in.

Aquaponic systems are a bit more complex than a regular hydroponic system because the nutrients are derived from the living ecosystem itself. Also with aquaponics there's usually a series of filtration tanks needed to remove the accumulating solids as well as the degassing of accumulating gasses like hydrogen sulfide, methane and nitrogen from the system. There is also the plant to fish ratio to consider, not enough fish equals not enough nutrients to support the plants.

Aquaponic Systems
Typically aquaponic systems consist of several parts. A rearing tank (fish tank), solids removal tank (to keep solids from building up in the system), bio-filter (to remove the accumulating chemicals and gasses, as well as promote the growth of the beneficial bacteria and microorganisms), hydroponic system (where the plants are grown without soil), and lastly a sump pump (that circulates the water supply).

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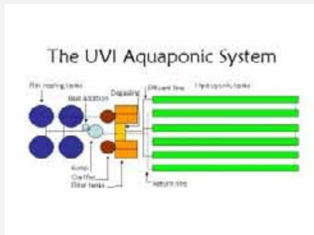
Depending on the setup type of a aquaponic system, it may or may not be using planter beds to grow the plants. Planter beds are like raised flower-beds that are usually filled with gravel (also called "gravel beds"). These gravel beds not only act as a bio-filter that strips out ammonia, phosphorus as well as other accumulating chemicals, so that freshly cleansed water can be recycled back to the fish tanks. But they are also the breeding ground for beneficial bacteria and microorganisms that break down the fish waste into the raw elements (nutrients) the plants can then absorb. These beneficial bacteria and microorganisms are essential to an aquaponic system working, because without them to turn fish waste into nutrients, the plants would not get the nourishment they need to grow.



Aquaponic systems that are not growing the plants in gravel beds, but rather using a more traditional hydroponic system like a water culture or flood and drain systems, still require the beneficial bacteria and microorganisms to work. These traditional hydroponic systems don't have the large surface area (like within the gravel beds) for the beneficial bacteria and microorganisms to largely grow and multiply. But they can be added directly to the water as a bacterial starter culture and grow in a separate in line bio-filter.

Growing the Fish

The fish of course are an important part of the aquaponic system. The most common fish that's raised in commercial aquaponic systems is tilapia. Some other fish that have been used include catfish, bass, crappies, trout, carp, pacu, goldfish and cod. Tilapia is a warm water fish so they can also tolerate higher water temperatures, though most fresh water fish that can tolerate crowding should do well in aquaponic systems.

There are typically three ways of fish rotation in commercial aquaponic setups, Sequential rearing, Stock splitting and Multiple rearing units. Sequential rearing is where multiple age fish are raised in the same tank, then when the oldest ones are ready to harvest they are selectively caught and removed. Then new baby fish are added to replace them. Stock splitting involves stocking very high densities of baby fish, then periodically splitting the population in half as they get bigger until there ready to harvest. Multiple rearing units involves using a series of sequentially larger tanks. As the fish get larger they are either herded through a hatch between adjoining tanks, or into "swim-ways" connecting distant tanks moving them all as a group into the next size tank. All the multiple rearing units are usually connected to one filtration system that feeds the plants.

An important factor is the water to plant ratio. That also has many variables, but can range anywhere from a 1:1 ratio to a 1:4 ratio. The variation in range depends on type of hydroponic system used (gravel vs. raft etc.), fish species, fish density, feeding rate, plant species, as well as the depth of the growing beds etc.. You need enough fish waste to provide a constant amount of nutrients, but you don't want waste to accumulate in the system or growing beds. The solids removal tank will take care of most of that, although if using the gravel beds solely as the bio-filter without a solids removal tank, solids can build up in the gravel beds.

Conclusion

Aquaponic systems are complex carefully choreographed living

ecosystems that can provide both fish and produce. But most commercial aquaponic farms need to run at full production for both fish and produce in order to be profitable. On the other hand, even though more complex than a regular hydroponic system, it can be quite rewarding to grow both plants and fish together. But be patient because it will likely take some time, as well as trial and error to get quite good at it (as with most things).

Useful Links
Recirculating Aquaculture Tank Production
Aquaponics—Integration of Hydroponics with Aquaculture
Aquaponic System – Design Manual
Classroom Aquaponics: Exploring Nitrogen Cycling in a Closed System
Barrel-ponics
On-Farm Food Safety: Aquaponics

October 15th, 2010 | Category: Hydroponic Nutrients, Hydroponic Reviews, Hydroponic Systems, Uncategorized | One comment

1 comment to Aquaponics or Hydroponics

Sylvia Bernstein
October 16th, 2010 at 9:26 am

You've done a pretty good job of describing how a commercial aquaponics system here, but please understand that the extra filtration complexity is only in a commercial raft, or DWC, system. In a media based system, which is what home and small scale commercial growers are using, there is no extra filtration and clarifying needed. It becomes a simple flood and drain system. The fish water is pumped directly into the media bed (gravel or Hydroton) where the ammonia is converted to nitrates by beneficial bacteria, and the rest of the waste is converted to the remaining elements the plants require through microbes and worms. The water returns to the fish tank clean.

I have grown for many years both hydroponically and aquaponically and I actually find aquaponics the easier of the two methods. I don't measure or worry about EC or ratios of Grow and Bloom formula, I just feed the fish. I never dump and replace my nutrient water. There is no pythium – ever. It is really a great way to grow, so thanks for bringing aquaponics to the attention of your readers!

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Build Your Own Hydroponics Bucket Drip System

Even though this system is designed to grow 4 plants in 5 gallon buckets, you can easily adapt it to grow more or less plants as you wish, as well as in larger or smaller

containers/buckets. You should be able to get all the materials needed at local stores like Home Depot, Lowe's, Wal-Mart, Target, Big lots, Kmart etc. I got the five gallon buckets at Home Depot for about $2.50 each, and the 18 gallon storage tote at Wal-Mart for $3.50. The black vinyl tubing and "T" connectors, I got at Lowe's. I also got the fountain pump from Lowe's (in the gardening section). That was the most expensive part of the whole system. The pump was about $40, but for this system you don't need a pump as large to do the job, but it does allow you to expand on the system in the future.

Just make sure any pump you use has a removable filter, If not you will want to create one to keep debris out of it. The Through holes/Bulkhead fittings come in all sizes and shapes. They are used in all sorts of industry's, but most home improvement stores carry them somewhere in the store, and very likely have them in more than one place. The Through holes/Bulkhead fittings come in all sizes and shapes. The ones that I used for this system I found at Home Depot for $1.97, right next to the electrical conduit.

System Parts List

- 4 Five Gallon Buckets (for plants)
- 4 Through

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Holes (also called bulkhead fittings)

- Black Vinyl Tubing (for both fill and drain lines), also blue Vinyl tubing from a hydroponic supply shop will work fine.
- 1 Submersible Fountain Pump
- 18 to 30 Gallon Storage Tote (for reservoir)
- Inexpensive Lamp Timer (with lots of on/off cycles to turn pump on and off with)
- Hydroponic Growing Medium (to support plants and hold moisture for the roots)
- One Inexpensive furnace Filter (to keep growing medium from getting in the tubing)
- A Few "T" Connectors that Fit the Vinyl tubing your using (how many depends on your final configuration)
- Two Cans of Inexpensive Black Spray Paint, and Two Cans of Inexpensive White Spray Paint (in order to light proof the buckets and reservoir)
- (Optional) A small amount of PVC tubing and connectors (for return line ends)

You will need to make sure the end of the through hole that the vinyl tubing will go on (end without the threads and nut), will fit the size tubing you are using. The ones I used will fit 5/8 inch inside diameter tubing. If not you can use two sizes of tubing and/or using a hose clamp to tighten it up. Also you may find that a old garden hose will fit just fine, and can be substituted for the vinyl tubing for the return (drain) lines.

Getting Started

First step is to trace the side of the through hole with the thread and nut, on the bottom of all 4, five gallon buckets. You'll want it to be close to the edge of the bucket, but not so close you wont be able the thread the nut on in order to install it (about an inch). That's so you will be able to set it upright on a table or bench, and most of the buckets weight will still be supported and it wont tip over.

I use a rotary tool to make the holes, but if You don't have one you can make the holes any way you want. Even a hot metal coat hanger will be able to melt the plastic nicely, then just scrape any burs off with a razor blade to make the edge soothe. It's important that you don't make the holes too big, or it may leak. It should be just big enough to stick the threaded side of the through hole in, without noticeable gaps. Now insert the through hole and tighten it up. Just make sure you have the rubber gasket on the right side. In most cases (depending on the particular through holes your using) it will most likely be on the outside of the bucket, and only the nut on the inside.

Now you'll need to light proof the buckets. Turn the buckets upside down, and put tape all around the through hole (so you don't get paint on or in it). Give the buckets a couple of coats of black spray paint, or as many as needed to block all the light. Then because the color black absorbs heat, give the buckets a couple of coats of white spray paint. This will reflect light and help keep the root zone temperatures from getting hot. Make sure you only paint the outside, you don't want paint to come in contact with the roots or nutrient solution.

The reservoir is quite simple, just paint the base and lid (outside) of the 18 to 30 gallon storage tote the same way you did the buckets. Painting it black to block light, and then white to reflect light. Once painted, cut a notch in the lid

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for the electrical cord and hose from the pump to go through. Then another hole or two for the return line/s where you plan it to be.

Setting the system up

There are so many different configurations to setting up the system, there's no way to explain them all. The buckets can be setup on a table, bench, wall etc.. But the one thing that you need to be sure of is that the reservoir is at least 6 inches below the buckets. Otherwise the nutrient solution wont be able to flow back into the reservoir. The design is simple, the pump pumps the nutrient solution up to the top of the buckets, where it drips down through the bucket, and out the through hole at the bottom. Then the return tubing drains it back into the reservoir.

You can run the return lines different ways, but it should be a gentle slope all the way back to the reservoir. You can see that I connected the return lines from two buckets together with a "T" connecter, then back to the reservoir. The PVC at the end of the line's going back into the reservoir is not necessary, although it does help keep the flow draining back more even. The tube coming out the side of the reservoir and looping back up through the center of the table, is the line that pumps up the nutrient solution from the pump to water the plants.

Getting the buckets ready to put the plants in is also quite simple, but just a few steeps. First cut the filter part out of the furnace Filter, then cut a piece off to place over the through holes. This will keep the growing medium out of the tubing, but still allow the water to flow easily out the bottom. Now that you have the filter in place, place some rocks on top of that. I would fill about the bottom third with rocks. This holds the filter in place, and adds weight to the bucket keeping them firmly in place. (Note:) Be sure to clean and sanitize the rocks first by soaking them in bleach water for about an hour, then rinsing again. This reduces the chances of any root diseases.

On top of the rocks place the growing medium. I like coco chips myself, and that's what I used when building this system. Coco chips and coco fiber are Basically the same thing, but the chips just larger partial sizes. Now make a loop using the vinyl tubing and a connecting "T" for all 4 buckets. These will be the dripper's that will water the buckets. Once you have made them, take a paperclip and heat one end up with the flame of a candle, then poke some holes in the tubing ring with it. Notice that I cut a notch in the side of the buckets just large enough to hold the watering line in place snugly.

As with the drain lines, the feed (watering) line setup will depend on the configuration and positing of where you place your buckets. In this picture you can see how I have run the lines to my buckets. The feed line comes up through a hole in the center of the table. Then is split into 2 lines using a "T" connector, then each of those lines is split into two lines again using the same "T" connectors. Essentially splitting one feed line into 4 separate lines (one to each bucket).

I used a digital timer

with this system (I already had it), but I later got another one for a different system for $5.95 at Kmart. It had plenty of settings and even a cover over the dial. For best results with the timer, make sure it 's rated for 15 amps (usually called heavy duty). You will also want a timer that has pins for the on/off cycles all around the dial, not just a few (for analog timers). That's because it will need to be turned on and off many times during the day. Digital timers usually have many on/off cycles that can be set.

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The Science Barge

With all the environmental issues facing the planet these days, it's not often you hear about real viable solutions to any of the problems that can be fully taken advantage of right now. But the Science Barge project (started in 2006) is one of those viable solutions. By taking common technology, and combining them together, the Science Barge project is showing that there's at least one answer to the planets problems that can be implemented today. Without waiting decades for the technology to be developed and perfected first.

The Science Barge is a floating, sustainable urban farm project, that's owned by Groundwork Hudson Valley in NY. There funded by federal, corporate, and foundation support as well as receiving individual donations. The Barge may be a small scale project, but the goal is to help educate and show future farmers that a self sustaining farm can be done on a large scale. By not only serving as a model for future farms, but it's also serving as an ongoing educational tool to students, collages and the general public. Another goal is to get people to think outside the box, by simply showing them that growing food can be done in lots more places then were conventionally thought to be unusable for crops, and food production. Can you imagine crops growing on rooftops, buildings, floating on lakes or oceans, suspended above parking lots and highways, on top of sports stadiums and Schools.

What makes the Science Barge different

The Science Barge program is a 135 foot long flat bottom boat based in Yonkers NY. that takes hydroponics and aquaponics, as well as being green to the next level. By using solar, wind, and bio-fuels (with no carbon emissions) to fully power the

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project. Water storage tanks hold rainwater from a rainwater catchment system, as well as a RO system (Reverse Osmosis) that purifies river water to irrigate the crops. The used water is also recycled so there is no waste-water run-off going back into the environment. The water demand for irrigating all the plants on the barge is about 75 to 150 gallons per day. that's less than 1/4 the demand for the same amount of field grown plants. The fruits and vegetables grown on the Science Barge also require seven times less space to grow than traditional field grown crops.

They get all of the electricity they need from wind, solar and bio-fuels. They have five internally regulated wind turbines (with a total 2.0 kW of power), two passive solar trackers, including solar charge controller and auto-transformer. These solar panels track the suns path for maximum efficiency (with a total 2.45 kW of power). All of this electricity is stored in a bank of battery's on-board the barge. The battery bank is capable of storing a two day reserve of needed electricity. But well you just never know, so they also have a generator that has been converted to run on used vegetables oil (bio-fuel), just in case. The barges daily power demand is about 25 kWh. Large farming operations that don't use all the electricity generated from the solar and wind generators, can also sell the excess electricity to the electricity company's for an added source of income.

Along with regular hydroponics, they are also utilizing the technology of aquaponics on the Science Barge. Aquaponics is a little bit different than traditional hydroponics, it's a process where the nutrients solution is created in a controlled living environment of living fish, water-plants, and microorganisms that break down the organic material (fish waste etc.), into the raw elements the plants can then absorb from the roots. Among other things, the aquaponic system on the science barge is home to crayfish, goldfish, catfish, and is able to grow editable food. The Science Barge also contains a small man made wetland area, that's located underneath the solar panels that is used to recycle the used water from the hydroponic, and aquaponic systems.

But is it really all that efficient?

The Science Barge is able to grow 2000 pounds of fruits and vegetables in an area about the size of a single bedroom apartment, all in a single growing season. Unlike field grown plants where there's only one growing season a year, because you control the plants environment when growing hydroponically, you can have anywhere from 4 to 8 growing seasons in a single year (depending on crop/plant). There's no off season in hydroponics, plants are grown and when their done their immediately replaced with new plants, all year long. So along with being able to grow 7 times more produce in the same amount of space, and using less than 1/4 of the water to do it, then multiplied by many more seasons per year in the same space. Well I'll let you do the math. And on top of all that, it's completely environmentally sustainable too.

The only downside would be the higher start-up costs, mainly from building

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the greenhouses, wind turbines, solar panels, and battery bank to store the energy. That's the main stumbling block, but due to the much higher yields will quickly more than pay for itself. Especially when you factor in all the savings from not needing all the very expensive heavy equipment needed to plow and condition the soil, spray pesticides, as well as harvest traditionally grown field crops. From my point of view, I don't see how we can afford to continue to grow crops the traditional way anymore.

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Science Barge FAQs
Science Barge technical description pdf.
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The Importance of Calcium for Hydroponics

There are so many different manufactures of hydroponic nutrients on the market, and you always here the question which nutrients work best. While the answer to that is really based on what plants your growing, simply because some nutrients are formulated for specific types of plants, and some nutrients are formulated for general use. But just about all commercially manufactured nutrients are formulated to provide a well balanced nutrient solution that will generally supply your plants with all the nutrients they need, and in the right ratios. But that doesn't mean your plants wont ever become deficient of some essential nutrient/s (element/s), and will never show any signs or symptoms of a deficiency. Even if there in abundant supply in the nutrient solution. This can be a calcium problem.

It's normal to think that if there's a deficiency in the plant, it must be deficient in the nutrient solution. But that's not always the case. Plant chemistry is a very complex process where each element affects others, as well as environmental conditions. Calcium is a major building block for plants, and like any other element, can become deficient in plants even when in plentiful supply in the nutrient solution. But a calcium deficiency is very difficult to diagnose because it has such a wide range of symptoms, and can simply look like other deficiencies and/or diseases.

Why Plants Need Calcium

Calcium is used in the plants cell walls during their formation, It's basically

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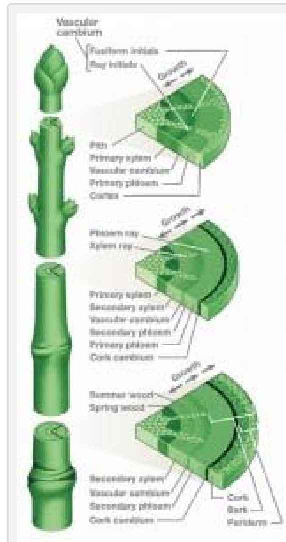
required for the stability and function of the cell membrane, and it acts like a kind of glue or cement, binding the cell walls together. So if adequate calcium is not in the cell tissue during the formation of the cell walls, the plant tissues will simply be less stable and prone to breaking down. It then can look like a wide verity of symptoms of disease and/or deficiencies, that also makes the plant tissue more prone to getting disease and viruses from other environmental conditions and/or insects.

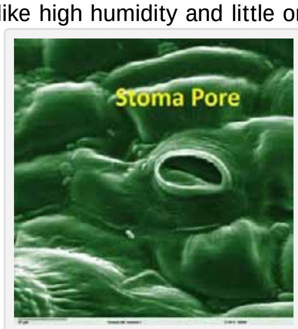
Once the cells are formed, the calcium is glued/cemented in place and becomes immobile. Because calcium has then become immobile within the plant, a constant supply of calcium is needed for healthy growth as the plant continues to grow. If there's a lack of calcium supply within the plant, once the cells are already formed, they can't be repaired by an increase of calcium supply to the cells that have already been formed. But the new plant growth can grow healthy and normal. When other elements are in excesses, calcium also helps act as a buffer for the root system. Calcium even plays a part in activating enzymes that regulate the flow of water movement within the plant cells, and is therefore vital for new cell growth and division.

Factors that Influence Calcium Availability



Plants have two basic types of tissues to transport the minerals and sugars they need for growth though the plant, the xylem and phloem. These act as the circulation system for the plant, like vain's and blood vessels in a human. The xylem vessels carry water along with the dissolved nutrients from the roots up stems to the leaves and fruit. Water is lost from the foliage by transpiration (like exhaling in humans), through small pours in the stems and leaves called stoma. This creates a suction which draws up water from the roots through the xylem vessels, and distributed all around the plant.

Any condition that affects plant transpiration will affect the water flow/uptake through the xylem. Since the calcium is transported primarily through the xylem, this will affect the calcium nutrition of the plant. Slow uptake of water into the plant can lead to calcium deficiencies, even if there's plenty of calcium in the nutrient solution. Therefor encouraging transpiration is one of the best ways to ensure the plant is getting the calcium it needs all the time. Environmental conditions like high humidity and little or no air flow, slow down transpiration of the plant. Adding ventilation is the simplest way to encourage plant transpiration. High temperatures and water stress also affect calcium intake. Keeping the plants stress free, with good ventilation, will go a long way to good calcium nutrition.



Also not all parts of the plant will transpire at the same rates. The tips and edges of new and/or fast growing foliage, as well as fruits tend to transpire at slower rates than the already established older foliage. Because of this, a calcium deficiency in the plant tissue can appear in the form of "Tip Burn" and/or "Blossom End Rot" (BER). But both Tip Burn, and Blossom End Rot can be caused by other things, making a calcium deficiency quite difficult to diagnose.

It's also important to maintain a well balanced nutrient solution. Most all commercially made hydroponic nutrients are well balanced. Although as the plants take up nutrients from the nutrient solution, the balance tends to be thrown off. Another important factor to consider is the strength of the nutrient solution, nutrient solutions that are too strong can inhibit calcium uptake from the plants roots.

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Using Ultraviolet Light, and Ozone Treatments for Disease Control in Hydroponic Nutrient Solutions

With any hydroponic nutrient solution, there can sometimes be unwanted pathogens, bacteria and/or fungi that can grow out of control in it. It's not uncommon for these disease and viruses causing microbes to be in the nutrient solution. In fact, it's very common for many different pathogens, bacteria, and fungi to be in the nutrient solution. it's just when the unwanted microbes grow into numbers that largely out weigh the beneficial microbes, that they can cause a problem. Much like the human immune system, the nutrient solution is a living environment, the beneficial microbes in the nutrient solution act as the plants immune system, keeping the damaging microbes at bay.

Once the pathogenic microbes get a strong foothold, they are very difficult to get back under control without doing damage to the plants. Simply changing the nutrient solution is not usually good enough, by then they have already imbedded themselves on the plants roots causing diseases and viruses. Once that happens, aside from constant care of fungicides and/or H2O2 treatments (that can also do damage to the plants). The only other option is the direct addition of beneficial microbes into the new nutrient solution once it has been changed, in hopes of keeping the pathogenic microbes from out numbering the beneficial ones again. But that wont fix any disease problems that may already exist, just helps keep it from getting too much worse. After that, the plants need to be discarded and the whole system needs to be sanitized to

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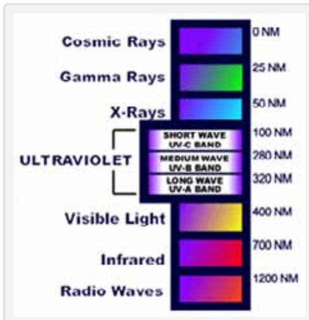
prevent recurrence.

How Ultraviolet Light (UV) Works

UV light has been used as a water purification system for well over 50 years, so it's not new technology. Although for hydroponic systems, it can be safely used to kill microorganisms without adding harmful chemicals like chlorine to the nutrient solution. Because the UV light only penetrates the water so far down depending on how strong the light source is. The nutrient solution is run through a tube where the water level is sufficient for the light to be able to penetrate all the way through the water. The water then runs through the tube at a flow rate that allows the light to have sufficient time for the UV radiation to kill the organisms. The UV radiation will kill most of the microorganisms directly, or it will sterilizes them. Once a microorganism is sterilized, it cant reproduce and simply dies.



The UV radiation treatment is safe for people and animals, so don't worry about glowing nutrient solutions, or glowing plants from radiation. In fact, many people subject themselves to direct UV radiation every day to get a tan at the tanning salon. Once out of the direct UV light (that's inside the tube) there is no more UV radiation, in which case new microorganism that haven't been subjected to the light source yet will be able continue to multiply. That's why the nutrient solution is generally run through the UV light (in the tube) on a continuously flowing basis, keeping new microorganism from being able to multiply.

How Ozone Treatments work

Ozone Treatment is similar to using an air pump to oxygenate the nutrient solution, although Ozone has an extra Oxygen molecule that is highly unstable. That doesn't mean that it's dangerous, just that the third molecule dissipates quite quickly (it has a very short half life). The added oxygen molecule makes Ozone a very powerful oxidizing agent, and can result in the elimination of the unwanted pathogens, bacteria and fungi that can cause the diseases and viruses to the plants. With Ozone Treatments, it's not easy to achieve good reliability due to the short half life, and difficulty in getting good concentrations of Ozone into the nutrient solution. For this reason Ozone Treatments are generally just used in commercial operations.

Ozone treatment systems require an ozone generator, and some of the oxygen from the air that flowers through the generator is converted into Ozone. Then just like an air pump and air stones are used to help oxygenate the nutrient solution, the ozone enriched air ($O3$) is pumped into the nutrient solution as a stream of bubbles. Contact time between the solution and Ozone bubbles is critical to it's efficiency, especially due to the very short half life of the ($O3$) molecules. The Ozone bubbles need to pass through a very deep solution tank usually called an "absorption tower," this allows the Ozone bubbles to stay in contact with the solution as long as possible for maximum efficiency.

Downsides to using Ultraviolet and Ozone treatments

Both ultraviolet , and Ozone treatments can breakdown some of the iron chelate in the nutrient solution, and that may cause some precipitation of manganese compounds. They also may reduce the "beneficial" micro-flora, which can play a role in suppressing plant disease and viruses. Also if you use any insecticides and/or fungicides in your nutrient solution, UV and Ozone treatments can also breakdown many of the organic compounds in them, once these organic compounds are broken down, some can become toxic to plants. Lastly Ozone can sometimes be damaging to certain plastic parts, mostly for commercially made NFT systems.

Useful Links

Ultraviolet Light Disinfection
Clean Water Supplies for Hydroponics
Hydroponic H2O: Water Quality and Treatment
Ultraviolet Disinfection Technology

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1 comment to Using Ultraviolet Light, and Ozone Treatments for Disease Control in Hydroponic Nutrient Solutions

Mulla Mahmadsoeb A.
August 27th, 2010 at 1:19 am

Respected sir,
I am student of Agricultural Engg,(B Tech),our projectis on HYDROPONIC.we are growing a cabbage plant in this. so we required information about the fertiliser(dosage/plant),plant spacing,etc. our project is NFT type, then what amount of time required to circulate the fertiliser,and the what amount of light intensity,temp, humidity.are required.

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Grafting Hydroponic Plants

The main idea behind grafting is to simply take a variety of plant with a desirable above ground characteristics, and connect it to the roots of a variety with desirable under ground characteristics. Grafting is a propagation technique where the living tissue of two different plants are joined, and fused together into one plant. The top part of a contributing plant can be stems, leaves, flowers, and/or fruits, this part is called the scion. The bottom part of the plant contributes the roots and support, this part is called the rootstock (or understock).

Although grafting usually refers to joining only two plants together, you can join as many as needed. Multiple grafts are commonly done with fruit trees. For instance in order to get multiple varieties of apples from one tree, or to get multiple varieties of citrus like lemons, limes, oranges, tangerines and grapefruit from just one tree. Grafting is not limited to trees, grafting vegetables and/or any other plant follows the same principle as grafting fruit trees.

Why Graft Your Plants

Besides just for the obvious fun of it, there a other reasons that grafting your plants may be useful. Some of these benefits include;

- **To Take advantage of a particular rootstocks**, Some rootstocks varieties may have superior growth habits, disease and insect resistance, drought tolerance, or may even be better adapted to a particular climate than that produced naturally by an ungrafted plant.

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Where the scion (top) of another variety may have a desired fruit size, flavor, or even plant size etc..

- **To Optimize cross-pollination**, Not all plants are self pollinating, some require pollination from another variety for good fruit set, and some plants have either male or female flowers but not both. To ensure good fruit set on the female flowers, a male plant must be growing nearby. Grafting a section of a male plant to a female plant can increase good cross pollination.
- **To Increase the growth rate of seedlings**, Grafting seedling onto a more mature plant can increase the growth rate of the seedlings because the root system is already established.
- **To Perpetuate clones**, Clones of some species of plants can't be reproduced from vegetative cuttings easily, because the percentage of cuttings that successfully root is quite low. But many of them can however be grafted onto seedling rootstocks.
- **Creating new Varieties** Some varieties of plants don't actually come from seeds. Some are difficult and/or just about impossible to reproduce strictly from cuttings or other techniques.

Grafting limitations

All kinds of plants can be grafted including fruits, vegetables, trees, bushes, flowers, but not all plants can be grafted together. The only real way to tell if it can be grafted is simply to try. But generally speaking plants that are closely related graft together best, and form a good graft union. A poor graft union usually results in plants that either grow poorly, break off or just eventually die.

Types of Grafts

Although there are many different so called types of grafts (Cleft Graft, Bark Graft, Side-Veneer Graft, Splice Graft, Whip and Tongue Graft, Saddle Graft, Bridge Graft and Inarch Graft) they all basically really come down to two types of grafting techniques, top grafting and side grafting. With top grafting the scion is matched to the new stem (plant) by placing it directly on top of the rootstock stem. In most cases the scion and understock are of exact or nearly equal size. Another type of top grafting consists of splicing the scion to the side of the stem of the new rootstock (even of different sizes). In which case several scions may be attached to a single rootstock, or stem of a rootstock. The different names (types) are just given to explain the different types of cuts used to match the two stems together.

With side grafting, a partial cut is made into the stem of the scion plant (leaving the rootstock attached), then placing it onto the cut-off stem of the rootstock. At that point both the top (scion), and the bottom (rootstock) still have their root systems attached. Once the graft has successfully formed a good union, the root system of the scion (top) is severed from it's original root system, leaving the scion to now live solely on the new rootstock.

Taking Care of the Graft

Both preparation, and post-graft care should be taken to insure success. It's usually better to do the grafting in the morning or late afternoon when it's cooler so they don't wilt, and to avoid water stress. Also if you can, it's best to do your grafting on cloudy days, in the shade, and/or in a cool greenhouse. You should keep the grafting area and cutting utensils as clean as you can (like cleaning off the cutting blade in-between cuts) to help prevent plant diseases from getting in the graft.

All graft cuts must be smooth and straight so they will fit and line up correctly. It's a good idea to practice by cutting some extra twigs of the same size as the ones you intend to graft. Once you have made the matching cuts, it's important not to let the cuts dry out. You shouldn't try to cut more plants than you can graft together in a few minutes in order to keep the cuts from drying out, and the plants from wilting. Although, you can wrap the cut ends in a wet towel, or place them in a cup of cool water temporary if necessary. When attaching the graft, you want to make sure the stems are lined up correctly in order to form a good union, also you'll want to wax over the cuts to help prevent diseases. Once complete you'll need to secure the graft, this can be done a number of ways (like wrapping, tying, clamps etc.) depending on the size, and what type of graft your doing.

After grafting, it's best to keep the plants in a warm but shaded place, about 80-85 degrees F. Also you should try to keep them in a place with high humidity (hopefully 95% relative humidity if possible) until the grafts heal. Regular misting is helpful as well to keep humidity high (just not real wet). It will likely take about a week for the graft to heal. Once the grafts heal, set

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them out in direct sunlight again a little longer each day in order to slowly acclimate them to the direct sunlight again. Continue to mist them if needed to prevent wilting. Once the grafts have healed and formed a good union, and shortly after growth starts (usually about 2 to 6 weeks depending on the plants), you'll want to remove the binding material such as string, cord or even some types of nursery tape to prevent Girdling (basically choking the plant) because they wont easily expand with the plant growth.

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Grafting Techniques For Greenhouse Tomatoes
Grafting and Budding Nursery Crop Plants
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Grafting, University of Missouri
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Grafting, University of Kentucky

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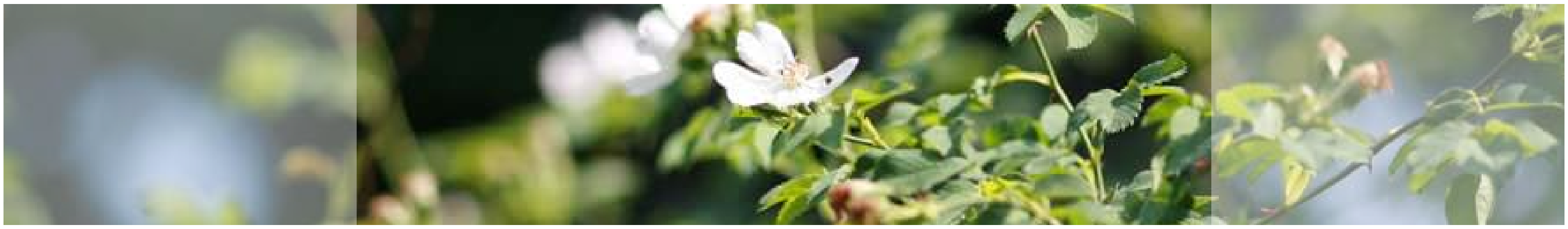

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Hydroponics in Antarctica

Who says you cant grow hydroponic crops anywhere? How about in the Antarctic, the coldest harshest continent on the planet. The only continent that has such harsh conditions there are no permanent human residents on the entire continent. The only residents are 1,000 to 5,000 people that reside throughout the year at research stations scattered across Antarctica. Out of all the dozens of research stations, only three are permanently manned year round, and they rotate the personal during the summer season. Well if you can grow hydroponic crops in that type of environment, you can grow hydroponically anywhere.

The National Science Foundation's Office of Polar Programs (NSF/OPP) oversees all of the research stations in Antarctica. Many of the research stations have built greenhouses to grow fresh produce to feed the crews manning the stations. This is especially important for the few research stations that are in operation year round. Supply's cant be flown in because like the north pole, most of Antarctica is in total darkness for about 4 months of the year. That combined with bad weather conditions like record lows of -117 F (without the wind chill), and unpredictable blizzard like winds, makes it extremely risky for planes to land and take off to bring in supply's most of the year. So these stations simply can't be re-supplied over winter months. All material and personnel must be flown in and stockpiled during the Summer season.

Once the supply planes stop after the Summer season, the fresh produce quickly runs out. So if there going to have any fresh fruits and

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vegetables during these long cold months, they simply need to grow it all on site at the research station themselves. The availability of fresh fruits and vegetables for meals, as well as flowers in the dining and recreation areas, has a great effect and impact, to the overall morale of all the personnel during those long dark winter months.

Hydroponics in Antarctica is not exactly new, they have been using hydroponic systems in Antarctica scene the 1980's. Although it was not intended as part of the research, but just to help provide fresh perishable fruits and vegetables to the researchers, in order to make life at the research stations more bearable. Though over the years, and through trial and error from the personnel at the research stations, as well as their persistence, they have been able to make hydroponics on Antarctica quite productive. Providing as much as 250 plus pounds of food monthly with less than 700 square feet of greenhouse space.

The Antarctic Greenhouses

The Antarctic greenhouse at the McMurdo (US) research station is not your ordinary greenhouse though. With the help of the researchers in Antarctica, the University of Arizona's "Controlled Environment Agriculture center" has developed the most sophisticated state-of-the-art growth chamber (greenhouse) on the planet. It's also a prototype for space stations, including those future stations planed for the Moon, and Mars. It's called the "South Pole Food Growth Chamber" (SPFGC) Project. The Growth Chamber was first completed and delivered to the South Pole McMurdo research station in February of 2004.

It's a completely sealed, automated atmospheric, CO_2 enriched, climate controlled greenhouse. This includes recalculating the waste heat given off by the water-jacketed HPS lamps to supplement the heat needed to heat the greenhouse. Also the hydroponic nutrient delivery system, and pH adjusting system, as well as all the environmental conditions are computer controlled by the ARGUS agricultural environmental control system and equipment. It records, controls and displays all key aspects of the environmental conditions for current, and later analysis. The Growth Chamber is fully operated by volunteer's at the research station, and with each personnel change the new personnel needs to be trained to operate it all.

Some of the typical hydroponics crops grown in the Antarctic include tomatoes, lettuces, spinach, various dark leafy greens, cucumbers, bell and hot peppers, beans, zucchini, snow peas, fennel, as well as all kinds of herbs. Growing hydroponically allows the grower to grow out of season crops as well as all year round, and with the fully climate controlled greenhouse it's always the perfect season for the plants. By using this to their advantage, that allows the personnel in Antarctic to continually rotate the plants so they always have fresh ready to eat produce from there crops.

Also by germinating seedlings on a regular basis, they make sure they always have replacement plants ready to place in the hydroponic systems once they have harvested the older ones. This significantly reduces the time that's needed to go from seeds to maturity (or before they begin to fruit), and helps to make sure they have a continuous supply of fresh produce all the time.

Conclusion

Well perhaps ordering your own "South Pole Food Growth Chamber (SPFGC)" is out of the question, but it just goes to show that just about anything can be done. Not many of us have such extreme conditions to deal with, but all it takes is some trial and error, persistence, patients, and ingenuity to find a way to solve any conditions and/or problems that you may be facing with your hydroponic gardens.

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Hydroponics FAQ

Old Bulletin Board

New: Hydroponics Forums:

Newbie home gardener
Growing Hydroponic Raspberries, part 2
diy climate control system
newbie likes this forum
Growing Hydroponic Raspberries
Light Wavelength
What nutrients to buy?
Best Inline Fans
What could be the cause of BER considering

Free Stuff

Build your own hydroponic gardens!

the cercumstances listed below
SSR for lights

Hydroponics Online School

LESSON ONE Introduction to Hydroponics

Hydroponic Systems

- Hydroponic Kits
- Ebb and Flow
- Aero Garden
- Hydrofarm
- Cloning
- Drip Systems
- General

Hydroponic Grow Lights & Bulbs

- LED
- HPS
- HID
- Metal Halide
- Fluorescent
- Conversion

Hydroponic Tents & Grow Boxes
Hydroponic Ballasts
Grow Light Reflectors
Hydroponic Nutrients
Grow Media Rocks
Hydroponic Pumps
Hydroponic Pots
Hydroponic Books
Hydroponic Seeds

Member Projects Page
This months feature members garden.
Koos Rautenbach's Garden

Hydroponic Supplies Online Store
Order gardens or hard to find parts.

Glossary
Terms we will use here on HOL

Design a Hydroponics Garden

Disclaimer
Please read this before you build a garden.

How to Build HydroRon's 11 Plant Garden
Complete gardens for sale if you don't have time to build one yourself.

Hydroponic Lighting

Led Grow Lights have many advantages over conventional grow lights,
read through our latest aritcle: Basics of Artificial Light for Hydroponics

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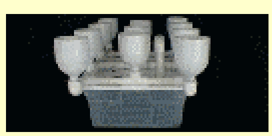

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Introduction to Hydroponics

Hydroponics by definition, means 'water-working." In practical use, it means growing plants in a water and nutrient solution, without soil. Hydroponics allows a gardener to grow plants in a more efficient and productive manner with less labor and time required.

The science of hydroponics proves that soil isn't required for plant growth but the elements, minerals and nutrients that soil contains are. Soil is simply the holder of the nutrients, a place where the plant roots traditionally live and a base of support for the plant structure.

In hydroponics you provide the exact nutrients your plants need, so they can develop and grow. The hydroponic nutrients are fed directly at the root base, never stressing the plant due to lack of nutrients or water.

Virtually any plant will grow hydroponically, but some will do better than others. Hydroponic growing is ideal for fruit bearing crops such as tomatoes, cucumbers and peppers, leafy crops, like lettuce and herbs and flowing plants. Most hobby hydroponic gardeners plant crops similar to what they would grow in a soil garden

Most commercial hydroponic growers combine hydroponic technology with a controlled environment to achieve the highest quality produce. Within a green- house structure you can control the ambient temperature, humidity and grow light levels allowing you to grow on a year- round basis.

Advantages of Hydroponic Growing

There are many advantages of hydroponic growing. These include:

- Most hobby hydroponic gardens are less work than soil gardens because you do not have soil to till or weeds to pull.
- By eliminating the soil in a garden, you eliminate all soil borne disease
- A hydroponic system uses a fraction of the water that a soil garden does because no water is wasted or consumed by weeds.
-

In hydroponics, plant spacing can be intensive, allowing you to grow more plants in a given space than soil grown produce.

- A small hydroponic garden can be set up almost anywhere.
- By providing the exact nutrients your plants need, they will grow more rapidly and produce bigger yields.
- In studies it has been proven that hydroponic produce is higher in nutritional value than field grown crops.
- Hydroponic produce generally tastes better than field-grown produce.
- If you are growing indoors in a grow tent, grow box, or in a greenhouse, you can grow your hydroponic plants on a year-round basis.

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Four Primary Hydroponic Growing Methods:
In a soil garden, plants are rooted in the soil and draw nutrients from it. In hydroponics, a nutrient rich solution
is fed directly to the plant roots. In some hydroponic growing systems an inert growing medium, such as perlite, rockwool or expanded clay pebbles is used in place of soil. These growing mediums are porous and absorb the nutrient solution, allowing the plants to use it as needed.

In other hydroponic systems, like the NFT system, no growing medium is used and the plant roots are suspended
in a grow channel.

The four most common methods of hydroponic gardening include:

- Ebb and Flow
- Drip Method
- Nutrient Film Technique (NFT)
- Passive System

Ebb and Flow
The Ebb and Flow (also know as flood and drain) method of hydroponic gardening simply allows all the plants
in the garden to be fed the same amount of nutrient solution at the same time.

HydroRon's 11 Plant

Ebb and Flow Garden

The plant grow bed, which contains plant pots filled with a growing medium, is flooded with the nutrient solution for a set period of time and then allowed to drain for a set period of time. This allows the growing medium and plant roots to stay moist while bringing fresh oxygen to the root base each time the nutrient solution drains away.

Most Ebb and Flow systems will flood the grow bed for 10 or 15 minutes of every hour or two In an Ebb and Flow system, the plant roots are most commonly grown in a medium of perlite, rockwool or expanded clay pebbles.

An Ebb and Flow system, popular with many home hydroponic gardeners, is ideal for growing a broad variety
of crops since both long and short term crops do well in this system.

Drip

In a Drip system, the nutrient solution is delivered to the plants through drip emitters on a timed system. The timed cycle flushes the growing medium, providing the plants with fresh nutrients, water and oxygen as the emitter is dripping.

Gallon Drip System

The emitters are usually scheduled to run for approximately 5-10 minutes of every hour. In a drip system, the plant roots are most commonly grown in a medium of perlite, grow rocks or rockwool. The drip system is often used in commercial hydroponic facilities that grow long term crops like tomatoes, cucumbers and peppers.

NFT

With the Nutrient Film Technique (also known as NFT) the plants are grown in
channels which the nutrient solution is pumped through.
The plant roots are flooded by the nutrient solution as it passes by. Ideally, the bottom of the roots are exposed to the nutrient solution, while the top of the roots are exposed to air. Most NFT systems are fed on a very frequent timed cycle. For instance, 10 minutes of nutrient solution flow, followed by 5 minutes of nutrient solution drain. Since the plant roots are not in a growing medium, it is crucial that they are flushed often to keep them moist.

NFT is ideal for lettuces, leafy crops and herbs, all of which are short term crops. Larger NFT channels can be used long term crops as long as some form of plant support is provided..

Passive

The advantage of a Passive hydroponic garden is its low maintenance. A Passive system does not use pumps or timers to flood the root zone. The roots usually dangle in the nutrient solution and draw what they need from it. A Passive system is generally slower growing and not as intensive as the other systems discussed.

Because there is no water movement, passive hydroponic growing systems will often have low oxygen levels. this can be remedied by adding a small air pump that pumps air into the nutrient reservoir.

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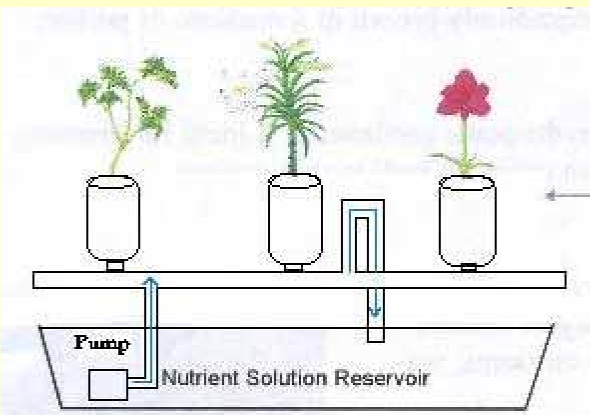
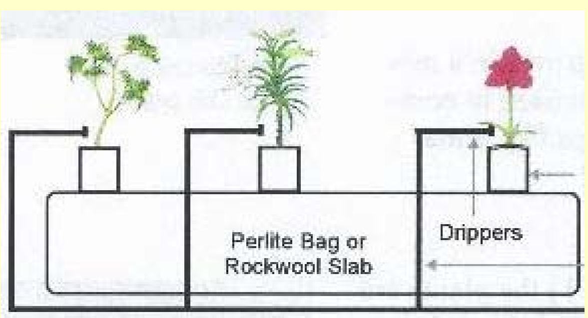
Four Primary Hydroponic Growing Methods



Ebb and Flow

Plant pots filled with growing medium

The nutrient solution is pumped from the reservoir up into the garden for a given period of time, the growing medium absorbs the nutrient solution, and then the nutrient solution is allowed to drain away.



Drip System

Rockwool Cube

Drip Line

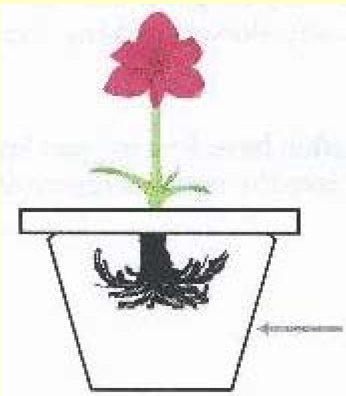
to nutrient reservior

The nutrient solution is dripped onto the growing medium on a timed basis providing the plants with fresh water, nutrients and oxygen.

NFT

Side view of grow channel in from nutrient reservoirÝÝÝÝ

The plant roots develop in the grow channel. The top of the roots are exposed to air. The bottom of the roots are exposed to the nutrient solution.



Passive System

Stagnant Nutrient Reservoir

Although nearly maintenance free, most passive systems will have slower growth and development since there is no fresh oxygen brought into the root base.

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Hydroponic Growing Mediums:

In a traditional garden, plant roots are in the soil. They support the plant and search for food and water. In hydroponics, we often use a growing medium in place of soil. The roots of a hydroponic plant do not work as hard as those of a plant grown in soil because their needs are readily met by the nutrient solution we feed them.

Ideal mediums are chemically inert, porous, clean and able to drain freely.

Many materials have been used as hydroponic growing mediums. These include: vermiculite, saw dust, sand, peat moss and, more recently, rockwool, perlite and expanded clay pebbles. Today's popular growing mediums, perlite,
rockwool and expanded clay pebbles are described below

Perlite

Perlite is derived from volcanic rock which has been heated to extremely high temperatures. It then explodes like popcorn, resulting in the porous, white medium we use in hydroponics. Perlite can be used loose, in pots or bagged in thin plastics sleeves, referred to as "grow bags"
because the plants are grown right in the bags. Plants in perlite grow bags usually set up on a drip feed system. Perlite grow bags usually hold 3 or 4 long-term plants.
Perlite is also used in many commercial potting soil mixes.

Plants grown in perlite

Rockwool:

cucumber seedling emerging

Rockwool is derived from basalt rock. It too is heated to high temperatures but then is spun into
fibers resembling insulation. These fibers are spun into cubes and slabs for hydroponic production.
The cubes are commonly used for plant propagation and the slabs are used similarly to the perlite grow bags. A plant is set onto the rockwool slab and grown there. The plant roots grow down into the slab. Rockwool slabs usually hold 3or 4 long term plants.

from rockwool cube

Expanded Clay Pebbles.
Growrocks

Many hobby hydroponic gardeners use expanded clay pebbles for their growing medium.
Expanded clay pebbles have a neutral pH and excellent capillary action. Often Ebb and Flow systems use expanded clay pebbles in the grow pots as the growing medium.


Expanded clay pebbles

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Water Holding Abilities of Hydroponic Growing Mediums

Students: ______________________ ______________________

______________________ ______________________

Date: ______________________

	Hydroponic Growing Mediums	Amount of water absorbed by the growing medium
#1		.
#2		.
#3		.
#4		.

#5		.	
#6		.	
#7		.	
#8		.	
#9		.	
#10		.	
#11	.	.	

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Homework / Review

Student:____ Date:________________

1. What is the literal definition of hydroponics? ____

2. In practical use, hydroponics means: ____

____

3. List three advantages of growing hydroponically

(1)_______________________________

(2)_______________________________

(3)_______________________________

4. The four primary methods of hydroponic growing are:

(1)_______________________________

(2)________________________________

(3)________________________________

(4)________________________________

5. NFT is ideal for growing short term crops like lettuce and herbs. True / False

6. Most commercial hydroponic growers use a passive system to grow their crops. True / False

7. The Ebb and Flow method is also know as the Flood and Drain method. True / False

8. In many hydroponic systems, a growing medium is used in place of soil. True / False

9. A growing medium should not be porous. True / False

10. Three commonly used growing mediums are:

(1)________________________________

(2)________________________________

(3)________________________________

LESSON ONE

Introduction to Hydroponics 1-8

Lighting Your Hydroponics Garden

There are four basic building blocks on which plant life is based: Light, Water , Nutrition, and Climate.
The most common factor that limits plant growth is the light source. Gardening outdoors, this obviously is not a problem; Mother Nature has seen to proper light balance and intensity for healthy plant growth. The responsibility for proper indoor lighting falls on the gardener. If your plants are not furnished enough light of the correct spectrum, they often will be mere shadows of what they could have been, if they grow at all. When you can't rely on Mother Nature to handle the lighting for you, the next best thing is a High-Intensity Discharge (HID) Metal Halide light system.

It is hard to compare HID lights with fluorescent tubes or incandescent light bulbs. Although they each create light from electricity, that's where the similarity ends. Fluorescent tubes emit a gentle, low temperature light in a very low wattage. Excellent for the first two weeks of most any plant's life, fluorescent lights simply do not provide the intensity of light required for most vegetables, flowers and ornamentals. Incandescent lights ('regular' light bulbs) are even worse for horticulture because they are very expensive to operate, put off as much heat as light, and do not offer the spectrums of light required for healthy plant growth. Even when incandescent light bulbs are altered with interior coatings to change their spectrum (like the "grow light" bulbs you see in the grocery store), they still do not come close to providing the kind of light a plant needs for robust, active growth. The only thing that will really grow and prosper under an incandescent grow bulb is your electric bill!

HID lighting systems represent the safest, most economical way of providing light for your plants. They are used all the time in parking lots, warehouses, baseball diamonds, football fields and other places where reliability and economy are a prime concern. Systems used for garden lighting are constructed differently, but the features of
dependability and cheap operation remain the same. Two common types of **HID** lighting have been adapted

for safe use in the garden and greenhouse, Metal Halide **and High-Pressure Sodium.**

Metal Halide light produces an intense light of a blue-white spectrum excellent for vegetative plant growth. Geraniums, marigolds, mums, zinnias, and violets all thrive under Metal Halide light, as do most vegetables. A plant grown under a halide light will often exhibit increased leaf growth, and strong stem and branch development. Roses grow hearty under metal halides, and seem to burst with buds before flowering time. A wonderful general purpose garden light, if your garden is to have only one light source, metal halide will be your best choice.

High-Pressure Sodium. (HPS) light puts off an orange: shaded light which simulates the rich red hue of the autumn sun. Best as fruiting or flowering. lights, the HPS systems are often used In conjunction with metal halide for a complete balance of light spectrum in the garden. Flowers and vegetables finished off under HPS will show tighter, stouter blossoms with increased yields. HPS lights are commonly used in commercial greenhouses as starting lights and for supplemental light for off-season crops. Some types of plants respond particularly well to HPS lighting, such as the herbs dill and coriander.

Average Lumen Per Watt Output of Common Lamps

100 Watt Light Bulb	*17.5* Lumens per watt
40 Watt Fluorescent Tube	22 lumens per watt
1000 Watt Metal Halide	125 lumens per watt.
1000 Watt High Pressure Sodium	140 lumens per watt

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F.A.Q

- How private will my medical records, and the things that I discuss with the physician be?
- What do I need to bring to my visit?
- What if I don't have any medical records to bring?
- What is the process of getting a recommendation like?
- Do I have to be at least 18 years old?
- What happens if I have never seen a physician but I know medical marijuana will help my condition?
- What verification service do you offer?
- Do you accept insurance?
- Do I have to make an appointment, or can I just walk in for an evaluation?
- What happens when I go to a dispensary with my medical marijuana recommendation for the first time?
- Who does the medical evaluation?
- Will you provide my personal information to the government, or any other agency?
- Do I have to pay if I do not receive a recommendation?
- Do I need to be referred by another physician?
- How do I set up an

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Our medical marijuana doctors are both understanding and compassionate, specializing in internal medicine and and alternative health. They are not afraid to recommend marijuana as an alternate medical treatment. We believe that no qualified patient should be denied access from wide ranging benefits that medical marijuana provides.

If you are in pain and.or suffer from a medical condition or disease that can benefit from cannabis use, consider coming in to get a legal marijuana recommendation from our medical marijuana clinic. Especially if you are currently using marijuana (cannabis) for your condition; you don't want to suffer the harsh legal penalties.

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appointment?
- What is the cost of an evaluation?
- How can I get a Medical Marijuana ID card from the county?
- Does local and state law enforcement recognize medical marijuana and its patients?
- How can I get my physician to send me my records?
- How many plants can I grow as a medical marijuana patient?
- If I get a recommendation now, will it help me with a past failed drug test?
- Can I be fired if my employer learns that I use medical marijuana as a legal patient?
- How can I be a caregiver for a medical marijuana patient, or have someone be my caregiver?

RESOURCES

- Informative Medical Marijuana Links

We are conveniently located near the intersections of the 5 and 55 freeways at the widely acclaimed North Park Plaza (on 17th St. between Grand and Lincoln)

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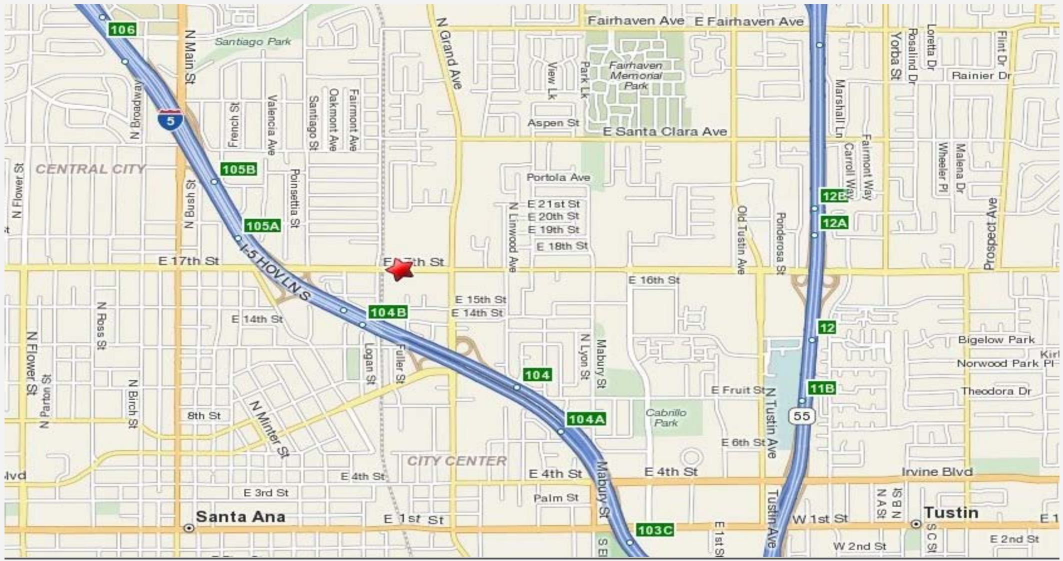

Click to get directions and/or view a larger interactive map via Mapquest.

Medical marijuana has been proven to be an effective treatment for various diseases, including, glaucoma, AIDS, anorexia, Parkinson's disease, Alzheimer's disease, and cancer. Years and years of research conducted in last several decades have been consistently supporting the value of marijuana for medicinal usage. Moreover, these studies are still running, and they continue to show more evidence of the medicinal benefits of marijuana.

If you have been suffering, medical marijuana may be right for you.

Orange County Medical Marijuana Card Evaluation Clinic - The Best Medical Marijuana Doctors for Medical Marijuana Recommendations in California

Is a Medical Marijuana Card right for you?

Obtaining a **medical marijuana card** could be the solution for your suffering from your illness, or injury. If you are sick and tired of trying expensive prescription medications, only to find out that your symptoms are not getting better, a **medical marijuana card** should be considered seriously. A **card** for medical marijuana may give you a rejuvenated sense of hope to combat any medical symptoms that may bother you.

In the past few decades, there has been a huge amount of anecdotal and scientific evidence in support of the relief that medical marijuana can provide for a vast array of symptoms. The following is a brief list of conditions for which medical marijuana can provide relief, and for which you may qualify for a medical marijuana card:

- Anxiety
- Diabetes
- Migraines
- Arthritis
- Fibromyalgia
- Nausea
- Anorexia
- Glaucoma
- Stress
- Asthma
- HIV/AIDS
- Seizures
- Chronic pain
- Insomnia
- Sports Injury
- Cancer
- Crohn’s Disease
- Multiple Sclerosis
- Depression
- Muscle Spasms
- Irritable Bowel
- And more…

Why You Want a Medical Marijuana Card:

1.) 100% Legal Access to Effective Medicine – Given all the evidence, its very difficult to dispute the medicinal value of marijuana/cannabis. It seems to be the only substance on Earth that can provide relief for the symptoms of:

- Chronic pain, Neck pain, AIDS/HIV, Gastritis, Sinusitis, Anorexia, Migraine headaches, Chronic back pain, PTSD, Premenstrual syndrome, Nausea
- Insomnia, Arthritis, and many more illnesses

as well as mental illnesses such as anxiety and depression without destroying your body (provided healthy intake methods) – all with no negative long-term side effects. Marijuana is an all naturally growing plant that’s been used as an effective medicine for thousands for years.

2.) Legal Protection – If you’re already using marijuana without a medical marijuana recommendation or medical marijuana card, you are breaking both state and federal laws. Even if you’re using cannabis/marijuana legitimately to treat a serious disease or to relieve yourself from excruciating pain, you are nevertheless violating state law if you are not in possession of a valid medical marijuana recommendation letter from a licensed physician.

By becoming a card-carrying medical marijuana patient you are given full legal protection under California's medical marijuana laws. Even if you get pulled over for a routine traffic ticket, you don't have to worry so long as you are carrying proof that you are a medical marijuana patient (in the form of a medical marijuana recommendation letter or medical marijuana card). The law is on your side now, but only if you have a **medical marijuana license!**

3) Use of California Medical Marijuana Dispensaries - In California alone, there are over five hundred medical marijuana dispensaries eager to serve the needs of its patients. With a medical marijuana card you now have access into medical marijuana dispensaries (aka cannabis clubs) in the state of California. Chances are, there is one in a few mile radius of where you live or work, which makes it very convenient to purchase marijuana. If you've been having a hard time having to buy marijuana locally from "drug dealers" and other unlicensed providers, you should seriously consider obtaining marijuana legally for your own personal safety as well as safety under the law. The best way to do this is to come into our medical marijuana clinic and get evaluated for a medical marijuana recommendation..

Nowadays, a visit to a medical marijuana dispensary in California very similiar to going to a coffeeshop in Amsterdam. Many medical marijuana dispensaries have dozens of cannabis strains to choose from, ranging from high end buds all the way down to schwag. Some even offer rooms where you can medicate on the spot, with more high end dispensaries having Volcano vaporizers inside to use. Vaporizers are a safe and healthy way intake the active ingredients of marijuana: they heat marijuana to the point where only the active ingredients are vaporized while the plant material is left unburnt. What this means is no harsh smoke to your lungs and a much more efficient way to medicate.

4) The Option of Growing Your Own Medicinal Marijuana – The State of California allows any valid medical marijuana patient with a medical marijuana recommendation to have up to six mature plants growing at one time. This is fairly large amount for your average user, given that up to 4 lbs of dried flower can be harvested from a single 6′ outdoor cannabis indica plant. We highly recommend growing your own medication for long term use while purchasing from dispensaries in the short term, especially in this recession. Growing medical marijuana is not only a great hobby, but a great way to make your own medicine and save money!

What verification service do you offer?

Patients can be verified 24 hours a day, 365 days a year using our online patient verification program. This online verification program will allow law enforcement and co-ops to verify your status. The online verification program is a secure way for patients to be verified.

Orange County Medical Marijuana Card Evaluation Clinic - The Best Medical Marijuana Doctors for Medical Marijuana Recommendations in California

DON'T BE FOOLED by unreasonably or suspiciously cheap operations and places operating out of store fronts
Make sure you are evaluated by a REAL DOCTOR, not a physician's assistant or nurse practitioner. All of our physician have over a decade of medical experience; you will see all certification when you come in.

We've been in business in the city of Santa Ana for over 9 years. We provide a multitude of health and medical services in addition to medical marijuana evaluations. For information on our other services visit:
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BE EXAMINED AND EVALUATED BY OUR LICENSED MEDICAL MARIJUANA PHYSICIANS ONLY.
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Each of our patients will receive a doctors exam with our California licensed medical marijuana physician. History, information, and signs will be taken and the doctor will determine if medicinal marijuana is right for you. If you are deemed eligible, you will be issued a **medical marijuana recommendation** and a **medical marijuana card**.

How to get a medical marijuana card in Orange County, California?

The best place to obtain a medical marijuana card in Orange County is through our clinic in Santa Ana. With pver 9 years of medical experience in Santa Ana, we, by far and wide, the most trusted and most reputable provider of medical marijuana recommendations in Orange County, California.

All their doctors are experts in holistic health and are fully licensed to practice medicine in the state of California. In addition, One Care's Medical Marijuana Clinic offers the highest quality patient ID photo cards, so you have something more convenient to carry around.

Many people are nervous about what a visit to a "medical marijuana doctor" will be like. Rest assured, there's absolutely no need to be nervous at all.

After you read this, you will feel much more comfortable about your visit. In fact, **you'll be surprised by how simple the whole process really is**.

What do I need to bring to my visit?

You will need to bring a **valid California Identification Card -** Valid California I.D. means a California Driver License or DMV issued I.D.

If you do not have a valid CA ID at the time, you'll need to bring in proof that you livein California in the form DMV paperwork **in addition** to some photo identification (i.e. Passport, Green Card, out of state ID, and school ID, etc).

It is also very helpful if you bring either medical records or documentation from your primary health care provider describing your diagnosis, although our doctor will evaluate you even if you don't.

1. When you come in for your medical marijuana evaluation appointment, you will fill out a questionnaire about your medication condition and the treatments that you've received for these conditions. You will be greeted by friendly, competent, and caring staff that will assist you in filling out all necessary paperwork.

These questions are asked so that when the doctor sees you, he already has an idea about your medical needs. The form is about 3 pages, and requires you to initial and sign (You can view copies of these forms on the left).

2. You will then present your California driver's license to the receptionist who will make a copy. If you don't have a CA drivers license, a photo ID in addition to proof of a California address will do. You'll then wait about 5-15 minutes until you are called. The average wait time is actually less.

3. The doctor will then see you and discuss with you what you have written down on your forms, especially the medical condition for which you are seeking relief via medical marijuana, and the treatments you've received (or not received) for your condition. The physician will determine your eligibility for use of medical marijuana to treat your condition. Our medical marijuana doctor will also discuss with you how marijuana works to help with your situation, and answer any question you may have about medical cannabis and health in general.

4. Depending on your situation, you may receive a brief physical examination, which will also focus on the condition in question. If you have documentation for your condition, that is best. However, if you don't, our medical marijuana doctor will see you anyway and help you.

5. You will then return to the waiting room while the doctor writes your medical marijuana recommendation. Your physician will determine the duration of your treatment protocol. **Recommendations are typically 1 year with valid medical documentation**.

Overall, the process is short and simple. Our patients are typically **in and out of the clinic in under 25 minutes!**

Unlike many clinics that require you to pay a fee up front, if our doctor decides that you are not eligible for a medical marijuana recommendation, **you don't pay a cent!**

We emboss your medical marijuana recommendation to make it official, you pay, and that's it.

It's that simple!

Why call us right now for your evaluation?

- **Completely Private Consultations and Medical Marijuana Evaluations - Guaranteed. We don't release any information to anyone unless you tell us to!**
- **If Don't Qualify You DO NOT PAY It's that Simple - 100% Risk Free**
- **Free and Fast Pre-Qualification Process Right Over the Phone**
- **Fastest and Easiest Way to Get Your Medical Marijuana Recommendation - In and Out in 25 minutes or less!**
- **Best Price for Medical Marijuana Evaluations in Orange County!**

We consider your privacy to be of the utmost importance. We follow strict HIPAA guidelines to ensure patient privacy. All patient records and discussions are kept in the strictest confidentiality.

The information between you and our office, as with any physician's practice, is completely confidential. The only time we would release any information about you is if a dispensary or club calls to verify that you are a valid patient of our office, or if a law enforcement agent calls to verify that you are a valid patient.

In these instances, they would ask us if the recommendation is valid, and what the expiration date of the recommendation is. They would not be provided with any other additional information about you such as your actual diagnosis.

It is not our policy to report or turn in any lists of names to any agency state or federal agency.

How to register your medical marijuana recommendation with the State of California:

The Medical Marijuana Program (MMP) was established to provide a voluntary medical marijuana identification card issuance and registry program for qualified patients and their caregivers. The web-based registry system allows law enforcement and the public to verify the validity of qualified patient or caregiver's card as authorization to possess, grow, transport and/or use Medical Marijuana in California. To facilitate the verification of authorized cardholders, the verification database is available on the internet at www.calmmp.ca.gov.

In 2003, Senate Bill (SB) 420 (Chapter 875, Statutes of 2003) was passed as an extension and clarification of Proposition 215, the Compassionate Use Act of 1996. The Medical Marijuana Program, within CDPH, is administered through a patient's county of residence. Upon obtaining a recommendation from their physician for use of medicinal marijuana, patients and their primary caregivers may apply for and be issued, a Medical Marijuana Identification Card. Senate Bill 420 also required that the MMP be fully supported through the card application processing fees. Both the state and the counties have authority to cover their costs for the program through these application fees.

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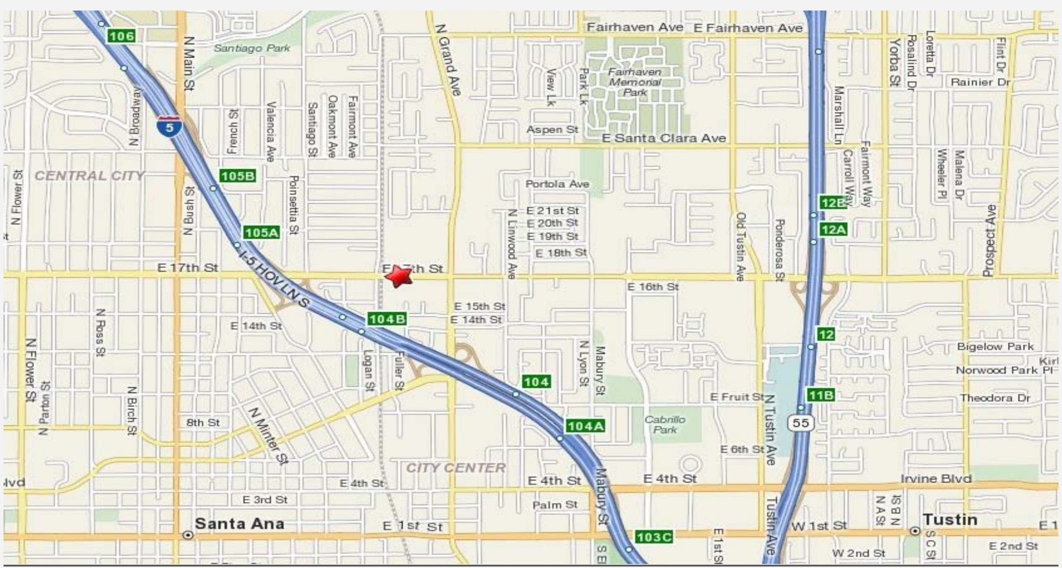

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Orange County Medical Marijuana Card Evaluation Clinic - The Best Medical Marijuana Doctors for Medical Marijuana Recommendations in California

Why Choose Us?

- **FREE Consultations** with warm, experienced staff.

- Our physicians & nurses combine extensive experience and expertise to provide you with the smoothest evaluation possible. We are committed to providing patients with a safe and professional medical marijuana evaluation
- Medicinal marijuana has proven to be a successful alternative health treatment for hundreds of aliments and diseases. We take pride in the superior professionalism that our patients can see.
- Our medical marijuana recommendations and multiple versions of the medical cannabis recommendation letter are **second to none**.
  Our standard physician letter is done on parchment paper- all information is typed into the letter and embossed with an **official seal**. We believe that our patients should not have to use an inferior medical cannabis cards and medical marijuana renewal recommendations.
- We are committed to comprehensive care for patients, from initial screening through all phases of treatment.
- Our world class 24/7 verification service is the highest quality in the industry.
- **VERY** Competitive pricing. Well known in Orange County to be the **most affordable**.
- Just because we offer value for money doesn't mean we won't offer you the best service we can. **Our friendly staff is always happy to make sure your visit goes your way**.

We've been in business in the city of Santa Ana for over 9 years. We provide a multitude of health and medical services in addition to medical marijuana evaluations. For information on our other services visit:
www.OneCareMedicalCenter.com

Frequently Asked Questions

How private will my medical records, and the things that I discuss with the physician be?
What do I need to bring to my visit?
What if I don't have any medical records to bring?
What is the process of getting a recommendation like?
Do I have to be at least 18 years old?
What happens if I have never seen a physician but I know medical marijuana will help my condition?
What verification service do you offer?
Do you accept insurance?
Do I have to make an appointment, or can I just walk in for an evaluation?
What happens when I go to a dispensary with my medical marijuana recommendation for the first time?
Who does the medical evaluation?
Will you provide my personal information to the government, or any other agency?
Do I have to pay if I do not receive a recommendation?
Do I need to be referred by another physician?
How do I set up an appointment?

What is the cost of an evaluation?
How can I get a Medical Marijuana ID card from the county?
Does local and state law enforcement recognize medical marijuana and its patients?
How can I get my physician to send me my records?
How many plants can I grow as a medical marijuana patient?
If I get a recommendation now, will it help me with a past failed drug test?
Can I be fired if my employer learns that I use medical marijuana as a legal patient?
How can I be a caregiver for a medical marijuana patient, or have someone be my caregiver?

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LESSON TWO

Hydroponics: Past, Present, Future 2-1

Hydroponics: Past, Present, Future

When you are first introduced to hydroponics, you may assume that is a new concept. That assumption is incorrect. Although hydroponics has become very high-tech, it is at least as old as the pyramids.

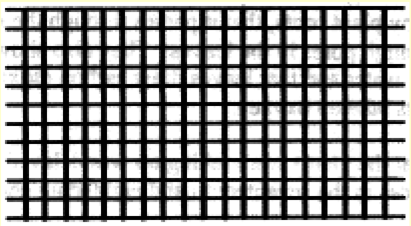
The First Hydroponic Gardens... 600 BC
Plants have grown in our lakes and oceans from the beginning of time but, as a farming practice, many believe it started in the ancient city of Babylon. The Hanging Gardens of Babylon are believed to be the first successful attempts to grow plants hydroponically.

Along the Nile, hieroglyphic records dating back several hundred years BC describe the growing of plants in water, without soil.

Before the time of Aristotle, Theophrastus (327-287 BC) undertook various experiments in crop nutrition. Botanical studies by Dioscorides date back to the first century A.D.

The Floating Gardens of the Aztecs
In the 11th century, The Aztecs of Central America, a nomadic tribe that was driven onto the marshy shore of Lake Tenochtitlan in the central valley of what is now Mexico, practiced hydroponic growing methods out of necessity. Without land to grow plants, they were forced to learn other ways of producing crops. Being a very ingenuous people, they built rafts out of rushes and reeds, lashing the stalks together with roots. They dredged up soil from the shallow bottom of the lake and piled it onto the rafts.

Chinampas
Floating Rafts of the Aztecs



Soil was taken from the bottom of Lake Tenochtitlan and placed on the rafts which were made of reeds, rushes and weeds. The soil was rich in organic debris which provided nutrients to the plants. Plants were placed on top of the soil. The plant roots grew through the soil and down into the water be- low. Some of the Chinampas were as long as 200 feet, growing vegetables, flowers.

Because the soil came from the bottom of the lake, it was rich in organic debris that held nutrients necessary for plant growth. Vegetables, flowers and even trees were grown on these floating rafts, called Chinampas. The plant roots would grow through the mats and down into the water.

The Chinampas were sometimes joined together to form floating islands as large as 200 feet long. Some Chinampas had a resident gardener who harvested and sold the vegetables and flowers on the raft.

As the Aztec village became huge, so did their floating gardens.
During the invasion of the Aztec villages by the Spaniards in the 16th century. these floating gardens were witnessed and documented. Such an innovative, yet productive plant growing system must have shocked the invaders.

U se of the Chinampas, or floating gardens, continued into the 19th century and some remnants can still be seen in Mexico today.

Other Examples of Hydroponics in History

Another example of hydroponics was described by Marco Polo in his famous journals. As he traveled through China (c1275 -c1292), he wrote of the floating gardens of the Chinese.

1600's: Early Scientific Experiments in Hydroponics:

In 1600, Belgian Jan van Helmont derived that plants obtain substances for growth from water by planting as lb willow shoot in a tube containing 200 pounds of dried soil. After 5 years of regular watering with rainwater, he found the willow shoot increased in weight by 160 lbs, but the soil lost less than 2 ounces. What he did not realize was that plants also require carbon dioxide and oxygen from the air.

In 1699, plants were grown in water containing various amounts of soil by John Woodward. a fellow of the Royal Society of England. Mr. Woodward found that the greatest growth occurred in the water which contained the most soil. He concluded that plant growth was a result of certain substances and minerals in the water, derived from the soil. This mixture of water and soil was the first man-made hydroponic nutrient solution.

European plant physiologists established many things in the decades that followed Woodward's research. They proved that water is absorbed by plant roots, that it passes through the plants stem system and that it escapes into the air through pores in the leaves. They also showed that plant roots take up minerals from either soil or water and that leaves draw carbon dioxide from the air. They also demonstrated that plant roots take up oxygen.

The determination of precisely what it was that the plants were taking up was delayed until the modern theory of chemistry made great advances in the seventeenth and eighteenth centuries.

In 1792 English scientist Joseph Priestly discovered that plants placed in a chamber filled with carbon dioxide will gradually absorb the carbon dioxide and give off oxygen. Two years later, Jean Ingen-Housz demonstrated that plants in a chamber filled with carbon dioxide could replace the gas with oxygen within several hours if the chamber was placed in sunlight. It was a fact that the plant was responsible for this transformation. eluding to the first concept of photosynthesis.

1800's -1920's: Great Scientific Breakthroughs
Between the early 1800's and the 1920's, phenomenal discoveries and developments were achieved in laboratory studies of plant physiology and plant nutrition. In 1925. the greenhouse industry expressed interested in the newly acquired knowledge in "Nutriculture," as it was called at that time. Between 1925-1935, extensive development took place in converting the laboratory techniques of nutriculture to large-scale crop production.

1930's: Dr. William F Gericke
In the late 1920's and early 1930's, Dr. William F. Gericke of the University of California at Berkeley, focused his research on growing practical crops for large scale commercial applications. During this time, he coined the term, "hydroponics", which was derived from the Greek words, hydro (meaning water) and ponos (meaning labor) literally "water-working." His work and research is considered the basis for all forms of hydroponic growing even though it was primarily limited to water culture without the use of a growing medium.

Dr. Gericke was photographed with tomato plants that exceeded 25 ft. in length. These photographs appeared in newspapers throughout the country and created both excitement and skepticism in the general public. Promoters and equipment manufacturers proceeded to cash in on the media-hype by selling useless equipment and materials promoted to grow goliath plants.

In reality, Dr. Gericke's newly developed hydroponic growing system was far too scientific and complex for most potential commercial growers.

1940's: Hydroponic Technology Used in W W II to Feed Troops
During the late 1940's, a more practical hydroponic method was developed by Robert B. and Alice P. Withrow, working at Purdue University. Their system alternately flooded and drained a container holding gravel and the
plant roots. This provided the plants with the optimum amount of both nutrient solution and air.

During World War II the shipping of fresh vegetables overseas was not practical and remote islands where troops were stationed were not a place where they could be grown in the soil. Hydroponic technology was tested as a viable source for fresh vegetables during this time.

In 1945, the US Air Force built one of the first large hydroponic farms on Ascension Island in the South Atlantic, followed by additional hydroponic farms on the islands of Iwo Jima and Okinawa in the Pacific, using crushed volcanic rock as the growing medium and, on Wake Island west of Hawaii, using gravel as the growing medium. These hydroponic farms helped fill the need for a supply of fresh vegetables for troops stationed in these areas.

During this time, large hydroponic facilities were established in Habbaniya, Iraq and Bahrain in the Persian Gulf, to support troops stationed in those areas near large oil reserves.

The American Army and Royal Air Force built hydroponic units at various military bases to help feed troops.

In 1952, the US Army's special hydroponics branch grew over 8,000,000 lbs. of fresh produce for military demand. Also established at this time was one of the world's largest hydroponic farms in Chofu, Japan, consisting of 22 hectares.

Following the success of hydroponics in W W II, several large commercial hydroponic farms were built in the US, most of which were in Florida. Due to poor construction and management, many of these farms were unsuccessful.

1945-1960's: Use of Hydroponic Culture Expands

Because no soil was needed and, with proper management optimum results could be had, the excitement over hydroponics continued and its use expanded throughout the world, specifically in Holland, Spain, France, England Germany, Sweden, the USSR and Israel. Areas with little rainfall, poor or no soil and difficult access were ideal for hydroponic culture.

Between 1945- 1960's both individuals and garden equipment manufacturers were designing hydroponic units for home use. Some were quite efficient while others failed due to poor growing media, unsuitable construction materials, poor construction and improper environmental control.

Even with many failures, the idea of creating the ultimate growing system intrigued many and research and design continued in the field of hydroponic culture.

1970-80's: New Technology Brings Hydroponic Production into Mainstream

In the mid 1970' s another media blitz about the miracles achieved with hydroponic technology hit the United States. Again, hydroponics was considered a get rich quick scheme and many hopeful investors lost big money on failed hydroponic farms.

Even though the potential of hydroponic culture is incredible, commercial hydroponics in the US was held back until hydroponic systems that were economical to build and relatively easy to operate, became available in the marketplace. With the advent of high-tech plastics and simpler system design, this came about in the late 1970's. The energy saving poly greenhouse covers, the PVC (or similar) pipe used in the feed systems, the nutrient injector pumps and reservoir tanks are all made of types of plastic that weren't available prior to the 1970' s.

As both small and large hydroponic farms were established in the late 1970's, it was proven that, with proper management, hydroponic culture could produce premium produce and be a profitable venture. As hydroponics attracted more growers, complete plant nutrient formulas and hydroponic greenhouse systems were being marketed. Environmental control systems were being developed to help to growers provide the ideal plant environment in addition to the ideal plant diet.

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LESSON TWO

Hydroponics: Past, Present, Future 2-2

Present

Hydroponics today is also referred to as "soilless culture." Soilless culture may or may not use a growing medium but, in either case, it is the nutrients and moisture that plants are seeking out. By raising plants in soilless culture
you can be sure that every plant gets the precise amount of water and nutrients it needs.

Currently the US has corporate hydroponic farms that cover as many as 60 acres and produce large quantities of hydroponic produce. Often this produce, is shipped throughout the US. In addition, there are thousands of smaller hydroponic farms that cover 1/8 -1 acre that usually grow premium hydroponic produce and market it in their local area. The most common hydroponic crop grown in the US is tomatoes, followed by cucumbers, lettuce, herbs, peppers and flowers.

Commercial hydroponic greenhouse Antigo, WI

The demand for premium produce is so high in the US that the number of current hydroponic farms cannot meet
the demand. Every day hundreds of thousands of pounds of hydroponic tomatoes, peppers and cucumbers are flown in from Canada, Europe and Mexico.

In addition to the commercial applications of hydroponics, there are many home gardeners that maintain

hydro-
ponic systems. Because more crops can be grown in a small space, it is environmentally friendly and produces premium produce, hydroponic culture lends itself well to a small garden. A hydroponic garden can be set up indoors, in a windowsill, a patio, balcony or rooftop, making gardening available to those who do not have a traditional yard or access to soil.

World wide, hydroponics has become a well established technology. In arid regions, such as Mexico and the Middle East, India and Israel, hydroponic culture is helping to feed growing populations. Nearly every country in the world uses hydroponic culture on some scale. In some cases, hydroponic produce is strictly considered a premium or gourmet product. In others, hydroponic technology is utilized for producing staple crops and grain. Hydroponic technology is even used by some zoos for producing animal feed.

Commercial hydroponic tomato crop

The US Navy is growing fresh vegetables on submarines in highly specialized recirculating hydroponic systems
to help supply fresh vegetables for the crews.
NASA is experimenting with recirculating hydroponic systems to be used to feed people in space. Many experiments have been conducted in laboratories and on recent space shuttle missions.

With today's technology, a small hydroponic grower with just 5,500 square ft. of greenhouse space (that's 1/8th
of an acre) can grow as much as 50,000 lbs. of hydroponic tomatoes annually.

As a concept, hydroponics has been around since the beginning of time. As a science, it is quite new. Hydro-
ponics has only been used in commercial production for approximately 50 years.
In that time, it has been applied to both indoor and outdoor farms, to growing premium produce, to feeding third world countries and to applications in the space program.

The Future of Hydroponics
As the technology is refined, hydroponics may become even more productive, feeding people around the world
or even in space. Other areas where hydroponics could be used in the future include growing seedlings for reforestation, establishing orchards, growing ornamental crops, flowers and shrubs and integration with aqua-
culture, where the wastes provides nutrients to the plants and the plants help to purify the water the fish are living
in.

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hydroponicsonline.com LESSON TWO

Hydroponics: Past, Present, Future 2-3

Homework / Review

Student:____________________________ Date:__________________

1. Do your believe that hydroponic methods can help feed the world?_________________________________

2. Why? ____

____

____

3. Who created Chinampas? ____

4. What were Chinampas made of ?____

5. When was hydroponics first used to supply large quantities of fresh vegetables?____________________

____

6. Who first coined the term hydroponics?
 (a) John Woodward
 (b) Dr. Frederick Hydroponia
 (c) W.F.Gericke
 (d) Ian van Helmont

7. The term hydroponics was derived from the Latin words "hydro" and "ponos," literally meaning...
 (a) nutrient working
 (b) growing plants

(c) water working
(d) water growing

8. With the advent of____,commercial hydroponic growing became popular in the US and worldwide.

9. Today, the most common hydroponic crop in the US is ___________________________.

10. The US Navy is growing fresh vegetables on submarines in highly specialized recirculating hydroponic systems to help supply fresh vegetables for the crew. True / False

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LESSON THREE

Building a Hydroponic System 3-1

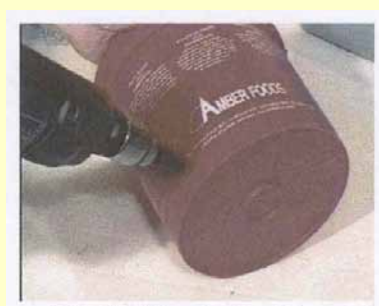
Building a Simple Ebb and Flow Hydroponic System

A simple ebb and flow hydroponic system can be built with some basic components: a bucket, a tub, tubing and a growing medium. This lesson instructs you how to build an Ebb and Flow system. If you have already built the 11 Plant Garden or have your own store bought garden then you can proceed to Lesson Four.

The procedure outlined below for building a hydroponic unit can be applied to a classroom project or can be used by a student for building their own hydroponic garden at home.

You will need:

- 1 bucket for your nutrient reservoir (2- 5 gallons)
- 1 tub for your plant bed (approximately l' x 2' x 6")
- 3 ft. plastic tubing, 1/2" diameter



- enough Growing Medium to fill the tub (plant bed)
- silicone or epoxy glue
- drill with 1/2" bit
- 2" x 2" piece of plastic screen or mesh
- 1 rubber band
- nutrient solution
- seeds or bedding plants from your local nursery

1. Drill a 1/2" hole on the side of the bucket, about 1" from the bottom
2. Insert the hose into the hole in the bucket and seal the edges of the hole with the glue.
3. Drill a 1/2" hole in the side of the tub (plant bed) about 1" from the bottom.
4. Insert the other end of the tubing into the hole in the plant bed, allowing the end of the tubing to protrude 2" through the bucket. Seal the edges of the hole with the glue. Allow time for the glue to dry .

5. Wrap the piece of screen around the end of the tubing that comes through the side of the plant bed and secure with the rubber band. This prevents the growing medium from clogging the tube.

6. Pour the growing medium into the tub, filling it to I" below the rim. Your Ebb and Flow hydroponic garden is now ready for nutrient solution and planting.

7. Fill your bucket with the mixed nutrient solution. Lift the bucket (higher than the grow bed) and allow the solution to run from the bucket into the grow bed. You can place the bucket on something higher than the grow bed white waiting for the nutrient solution to drain into the grow bed. When the growing medium is saturated, lower the bucket so the solution can drain back into the bucket.
(Mixing of nutrient solution is covered in Lesson 5)

8. Once your growing medium is saturated, you can plant your seeds. Follow the instructions on the

seed packet for planting depth. Or use starter plants from your local nursery. Carefully wash the lose medium from the bedding plant roots before putting the plants in the plant bed. *(See Lesson Six for more information)*

9. Once you have planted the seeds, the growing medium will need to be kept moist with nutrient solution. This is done by raising the bucket (flooding the grow bed) and lowering the bucket (draining the grow bed). This should be done several times a day to maintain a proper moisture level in the growing medium surrounding the plant roots.

You can automate this hydroponic garden by adding a small pump in your nutrient reservoir to flood the grow bed and a timer to start and stop the pump.

You will need to place your hydroponic garden near a window in direct light or, add artificial lighting. More information on proper lighting can be found in Lesson Seven.

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Meeting Plant Needs 4-1

Lesson Four -Meeting Plant Needs

Like humans and animals, plants have very specific nutritional and environmental needs that must be met in order for the plant to grow and develop. Both humans and plans must consume a balanced diet and need protection from harsh environments.

Plants all over the world have adapted to specific environ-
ments. A tomato plant, for instance, is a tropical plant and
thrives in average daytime temperature of 80 F and night-
time temperature of 60 F. When grown in temperatures
outside these parameters a tomato plant may survive, but
not thrive and, if the temperatures are too extreme, the to-
mato plant will die.

Individual species of plants have very specific nutritional

needs that must to be met. These needs may
vary through-
out the stages of the plant's growth.

For instance, a tomato plant needs more nitrogen during the vegetative growth stages and less nitrogen during the fruiting stages.
As a compromise to various needs and stages of growth, hydroponic solutions can generally be modified to be suitable for the majority of plants. For best results, it is a good idea to plant crops with similar needs together so the compromise in minimal.
In the soil, organic materials are broken down to release minerals and nutrients. They can then be dissolved in water, taken up by the roots and passed through the stem into the leaves. In hydroponics we provide the minerals a plant needs in a water-soluble form, ready to be taken up by the plant roots. We are therefore able to provide a very exact diet for our plants in the most usable form.
The more precisely a plant's needs are met, the more vigorous its growth will be. When you observe a lush, healthy plant, you can be sure that most or all of it's environmental and nutritional requirements are being met.

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Meeting Plant Needs 4-2

When growing plants in a **hydroponic garden, we must consider these factors:**

- the amount of water the plants need; proper drainage of growing medium
- the optimum temperature and light for the plant
- fresh air
- shelter and support
- pest and disease control
- the water-soluble minerals the plant needs
- the proper pH of the nutrient solution

Water:

As with all plant needs, the amount of water required depends on the species and the needs of that particular plant. A plant that suffers from lack of water will extend a huge, but not very effective root system, and will develop a very small plant above the ground. Many roots are sent out in search of water and when an inadequate amount is found, the plant will not grow to its potential.
In the other extreme, if a plant is over watered the roots can drown because they are not receiving the proper amount of fresh oxygen. This makes proper drainage of a hydroponic growing medium crucial to your plant's health.
The last consideration concerning the water you feed your plants is purity. In a hydroponic garden, you

should use as pure of water as possible. Water that has possible toxic contaminants or salt build ups may stunt or kill your plants.

Temperature and Light

The ideal temperature depends on the crops you choose to grow. Most of the common garden crops, such as tomatoes, cucumbers, lettuce, beans and peas will do well with an average daytime temperature of78 F and an average nighttime temperature of 64 F. Winter vegetables, such as cabbage, brussel sprouts and broccoli should be grown in slightly cooler temperatures.

Min / Max Thermometer

A minimum/maximum thermometer will allow you to track the low and high temperatures in your growing environment. This is important for monitoring overall progress of your hydroponic garden and diagnosing plant growth problems.

For optimum production, heating the root zone is important. For most garden crops 72 F is the ideal root zone temperature. Some growers achieve a heated root area by using heated grow mats placed under the growing medium. Another option is to heat your nutrient solution to the desired temperature and then when your system feeds the plants, the roots are bathed in warm water.

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Meeting Plant Needs 4-3

Fresh Air

Plants require adequate air circulation around the plants, as well as proper aeration in the root zone. Poor ventilation in the growing environment encourages mold, mildew and plant disease.
Many hydroponic gardens are located off the floor for better air circulation. Commercial hydroponic greenhouse growers use large fans and air circulation equipment to provide adequate air movement.

Shelter and Support

In a commercial application, many hydroponic farmers grow their crops inside of a controlled environment greenhouse. This not only provides shelter, but also an ideal, stress-free environment for the plant. Because many hydroponic gardens are quite small and very clean, they can be set up almost anywhere indoors, on a patio or a windowsill, making it easy for the gardener to provide shelter for the plants.
In a traditional garden, the soil anchors the plant and provides support. In hydroponics, the growing medium helps support the plant to some extent but

Tomato Plant supported by string and clip

most
often additional support is needed. Plant stakes,
strings,
and clips are used for this.

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Meeting Plant Needs 4-4

Pest and Disease Control

(see Lesson 9 for more information)

Since there is no soil in hydroponics, many, but not all plant diseases are eliminated. Well kept and clean growing environments are the best prevention when it comes to plant disease. Always remove dead or dying leaf matter and any unhealthy plants from your hydroponic garden.

If you are growing indoors, the chances of pest infestation are greatly reduced. In the event of pest problems, there are many biological controls available.

Water-Soluble Minerals (Nutrients in Solution)

(see Lesson 5 for more information)

As mentioned earlier, a hydroponic gardener uses minerals that are water soluble and ready to be taken up by the plant roots. Scientists and researchers have determined exactly what minerals a plant needs and in what quantities. A large number of hydroponic nutrient formulas have been developed and, although some have better results than others, there is no one perfect mixture. The success of each nutrient formula depends on the conditions it is used in and what plants are being grown.

Many hydroponic gardeners use a pre-mixed nutrient formula that they simply add water to. These formulas contain all the minerals and nutrients that a plant needs, in the correct proportions and are available in powder or liquid form.

The macro nutrients a plant needs include:

- Nitrogen
- Phosphorous
- Calcium
- Potassium
- Sulfur
- Magnesium
- Iron

and the trace elements (used in minute quantities) a plant needs include:

- Manganese
- Boron
- Zinc
- Copper
- Molybdenum

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Meeting Plant Needs 4-5

Proper pH

pH is the measurement of the hydrogen ion concentration in a particular medium such as water, soil, or nutrient solution. More simply, it refers to the acidity or alkalinity of that medium. PH is measured on a scale ranging from 0- 14, with 7 being neutral, above 7, alkaline and below 7, acidic.

The pH of a medium or nutrient solution is important to plant growth. Each plant has a preferred pH range. PH ranges beyond the preferred for a given plant may cause stunted growth or even death.

Very low pH (< 4.5) or high pH (> 9.0) can severely damage plant roots and have detrimental effects on plant growth.

As the pH level changes, it directly affects the availability of nutrients. The majority of nutrients are available to a plant at a pH range of 6.0 -7.5. Somewhere within that range is the ideal pH level for most plants. When pH levels are extremely high or extremely low, the nutrients become "locked" in solution and unavailable to the plant. At extremely low pH levels some micro-nutrients, such as manganese, may be released at toxic levels.

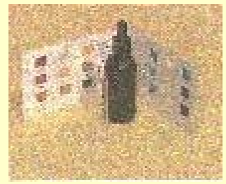
The newer and more popular growing mediums like perlite, rockwool and expanded clay have a neutral pH and will not alter your nutrient solution. Peat moss, saw dust, vermiculite and some of the other materials that have been used for hydroponic growing in the past are often unstable and will alter the pH of your nutrient solution.

The pH of your nutrient solution should be checked when you first mix it and then checked every few days when it is in your hydroponic reservoir.

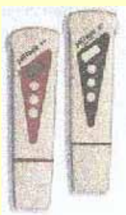
Three common methods of testing your pH

Litmus Paper: Simply dip the end of the paper into the solution to be tested and then compare the color of the litmus paper (which will have changed when dipped into the solution) to the color on the pH chart to determine the pH.

pH Test Kit: Take a sample of your solution in a vial and add several drops of the pH indicator. The sample will change color and can then be compared to the pH chart.



pH Test Kit



pH Test Pen

pH Pen or Meter. Simply dip the end of the pen, or the probe on a pH meter into the solution and it gives you a digital reading of the pH.

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Meeting Plant Needs 4-6

Altering Your pH:

If you find that your pH is too alkaline (too high), you can increase acidity (lower pH) by adding white vinegar, sulfuric acid or "pH-Down"

If you find that your pH is too acidic (too low), you can increase alkalinity (raise pH) by adding baking soda or "pH-Up."

When adjusting your pH, it is important to add small amounts, measuring as you go, until you know exactly how much to add per gallon of water to reach the desired level.

Following are target pH ranges for various garden crops:

- Beans 5.8-6.2
- Cabbage 6.3-6.5
- Cucumbers 5.7-6.2
- Eggplant 5.7-5.9
- Lettuce 5.7-6.2
- Melons 5.4-5.6
- Peas 6.3-6.5
- Peppers 5.8-6.2
- Radishes 5.8-6.2
- Strawberries 5.8-6.2
- Tomatoes 5.8-6.0

If you plan to grow a variety of crops, some compromise will be necessary. Again, growing plants with like needs together will yield the best results.

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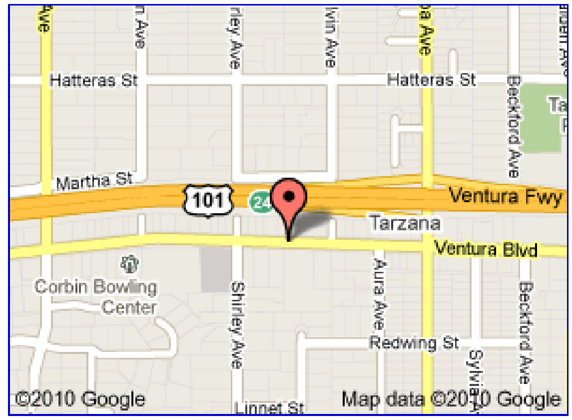

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www.hydroponicsonline.com LESSON FIVE

Nutrients Requirements and Testing 5 -1

Lesson Five -Nutrient Requirements and Testing

Many hydroponic formulas have been developed over the past 40 years with some designed for specific plants while others are designed for general hydroponic gardening. For plant growth, the concentration of individual elements must stay within certain ranges that have been determined through scientific experimentation.

The average concentration of these elements should fall within these parameters:
Nitrogen (nitrate form) 70 -300 PPM
Nitrogen (ammonium form) 0 -31 PPM
Potassium 200 -400 PPM
Phosphorous 30 -90 PPM
Calcium 150 -400 PPM
Sulfur 60 -330 PPM
Magnesium 25 -75 PPM
Iron .5 -5.0 PPM
Boron .1 -1.0 PPM
Manganese .1 -1.0 PPM
Zinc .02 -.2 PPM
Molybdenum .01 -.1 PPM
Copper .02 -.2 PPM

*PPM = parts per million

Plant Uses of Individual Elements:

Careful experiments using hydroponics have shown that each of the elements a plant needs has a very specific function in plant growth.

Nitrogen:
Nitrogen is a component of proteins, which form an essential part of protoplasm and also occur as stored foods in plant cells. Nitrogen is also a part of other organic compounds in plants such as chlorophyll, amino acids, alkaloids and some plant hormones.

Sulfur:
Sulfur forms a part of the protein molecule. Plant proteins may have from .5- 1.5% of this element. The sulfhydryl group is a very important group essential for the action of certain enzymes and coenzymes. In additional sulfur is a constituent of ferredoxin and of some lipids.

Phosphorous:
This element is also a component of some plant proteins, phospholipids, sugar phosphates, nucleic acids, A TP and NADP. The highest percentages of phosphorous occur in the parts of the plant that are growing rapidly.

Potassium:
Potassium accumulates in tissues that are growing rapidly. It will migrate from older tissues to merestematic regions. For example, during the maturing of the crop there is movement of potassium from leaves into the fruit.

Calcium:
All ordinary green plants require calcium. It is one of the constituents of the middle lamella of the cell wall, where it occurs in the form of calcium pectate. Calcium affects the permeability of cytoplasmic membranes and the hydration of colloids. Calcium may be found in combination with organic acids in the plant.

Magnesium:
Magnesium is a constituent of chlorophyll. It occupies a central position in the molecule. Chlorophylls are the only major compounds of plants that contain magnesium as a stable component. Many enzyme reactions, particularly those involving a transfer of phosphate, are activated by magnesium ions.

Iron:
A number of essential compounds in plants contain iron in a form that is bound firmly into the molecule. Iron plays a role in being the site on some electron carriers where electrons are absorbed and then given off during electron transport. The iron atom is alternately reduced and then oxidized. Iron plays a very important role in energy conversion reactions of both photo synthesis and transpiration.

Boron:
Although the exact function of boron in plant metabolism is unclear, boron does playa regular role in carbohydrate breakdown. Symptoms of boron deficiency include stunted roots and shoot elongation, lack of flowering, darkening of tissues and growth abnormalities.

Zinc:
Zinc is essential to the normal development of a variety of plants. Large quantities of zinc are toxic to plants.

Manganese:
The importance of manganese as an activator of several enzymes of aerobic respiration explains some of

the disruptive effects of a manganese deficiency on metabolism. The most obvious sign of a manganese deficiency is chlorosis. Manganese chlorosis results in the leaf taking on a mottled appearance.

Copper:
Copper is a constituent of certain enzyme systems, such as ascorbic acid oxidize and cyto chrome oxidize. In addition" copper is found in plastocyanin, part of the electron-transport chain in photosynthesis.

Molybdenum:
Molybdenum is important in enzyme systems involved in nitrogen fixation and nitrate reduction. Plants suffering molybdenum deficiency can absorb nitrate ions but are unable to use this form of nitrogen.

Hydroponic Nutrient Mixes

A gardener can purchase all of these minerals separately and mix their own hydroponic fertilizer. Unfortunately, the fertilizers that make up a hydroponic formula aren't sold as pure nitrogen or pure potassium, so it gets more complex. They are sold as chemical compounds, such as calcium nitrate, potassium nitrate, magnesium sulfate, potassium sulfate and mono potassium phosphate.

Since there are many dependable pre-mix hydroponic formulas available, it is generally more efficient and more economical to use a proven formula that contains all of the above mentioned nutrients in the correct quantities for plant growth. one that you simply add to water.

Whether you are using a pre-mixed formula or creating your own" it is important to follow these guidelines:

1. Weigh or measure the nutrients carefully.
2. Place the nutrients in separate piles or containers to be sure the proportions make sense.
3. Be sure no components are left out or measured twice.
4. Accuracy should be within 5 %.
5. When you are sure the proportions are correct, pour your nutrients into the water in the mixing containers and stir vigorously. Nutrients will dissolve best in warm water.
6. Measure the nutrient concentration level and record it.

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hydroponicsonline.com LESSON FIVE

Nutrients Requirements and Testing 5 -2

Nutrient Disorders

Nutrient	Deficiency	Excess
Nitrogen	Older leaves turn chlorotic and may eventually die. Plant is stunted Foliage is light green.	Plant becomes over vigorous, leaves become very dark green. Fruit clusters have excessive growth and fruit ripening is delayed.
Potassium	Older leaves appear chlorotic between veins, but veins remain green. Leaf edges may burn or roll.	Uncommon to show toxicity. Secondary manganese deficiency may occur.
Phosphorous	Stem, leaf veins, petioles turn yellow, followed by reddish-purplish as phosphorous is drawn from them	No direct toxicity. Copper and zinc availability may

	into the new growth. Seedlings may develop slowly. Fruiting is poor.	be reduced.
Calcium	Plant is stunted. Young leaves turn yellow. Blossoms die and fall off. Tomatoes may develop brown spots on the fruit.	No direct toxicity.
Sulfur	Younger leaves become yellow with purpling at base. Older leaves turn light green.	Small leaves.
Iron	New growth pales, veins stay green. Blossoms drop off. Yellowing occurs between veins.	Very uncommon.
Magnesium	Older leaves curl and yellow areas appear between veins. Young leaves curl and become brittle.	No direct toxicity.
Zinc	Leaves become chlorotic between veins and often develop necrotic spots.	Reduces availability of iron.
Molybdenum	Older leaves turn yellow and leaf margins curl.	Rare. Tomato leaves may turn bright yellow.
Copper	Pale yellow. Leaves become spotted. Plant is stunted.	May reduce availability of iron.

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Nutrients Requirements and Testing 5 -3

Deficiencies and Excesses
Since there is no soil to act as a buffer, your hydroponic crops will quickly respond to a nutrient deficiency or toxicity. Nutrient deficiencies are more common than excesses, with the most common deficiencies being nitrogen, iron and magnesium.

Deficiencies and excesses can be avoided by following a routine mixing procedure and schedule, daily monitoring of your nutrient solution and adequate feeding of the plants. If you have an extreme deficiency or toxicity, the plants will respond quickly and symptoms such as discoloration of foliage will occur. A minor deficiency or toxicity may not initially show symptoms but eventually will affect plant growth, vigor and/or fruiting.

Measuring Conductivity
Conductivity is a measure of the rate at which a small electric current flows through a solution. When the concentration of nutrients is greater, the current will flow faster. When the concentration of the nutrients is lower, the current will flow slower.

You can measure your nutrient solution to determine how strong or weak it is with an EC (electrical conductivity) or TDS (total dissolved solids) meter.

EC Meter

An EC meter usually shows the reading in either micromhs per centimeter
(uMho/cm) or microsiemens per centimeter (uS/cm). 1.0 uMho/cm is
equivalent to 1.0 uS/cm. A TDS meter usually shows the reading in milli-
grams per liter(mg/l) or parts per million (ppm).

EC is generally measured at 77 F (25 C). If the temperature of the solution is raised, the EC will read higher, even though no nutrients have been added. If the temperature drops below 77 F (25 C), the EC will decrease.
Therefore, it is important to always measure your EC at a consistent temperature of 77 F (25 C). Some EC and TDS meters compensate for varying temperatures.

Another measurement in conductivity is CF (conductivity factor) which is expressed on a scale of I -100. Pure water containing no nutrients is rated at 0 and maximum strength nutrients would rate 100.

Some general guidelines for EC levels are as follows:

	Fruiting Plants **(such as tomatoes, cucumbers)**	**Leafy Plants** **(such as lettuce, basil)**
Initial Growth (seedling stage)	1600 -1800 mMho/cm 1120 -1260 ppm	1400 -1600 mMho/cm 980 -1120 ppm
Average EC	2500 mMho/cm 1750 ppm	1800 mMho/cm 1260 ppm
Fruiting	2400 -2600 mMho/cm 1680 -1820 ppm	xxx
Low light conditions (winter)	2800 -3000 mMho/cm 2000 ppm	2000 mMho/cm 1320 ppm

High light conditions (summer)	2200 -2400 mMho/cm 1700 ppm	1600 mMho/cm 1120 ppm

In low light conditions (winter), a hydroponic grower should increase the concentration of nutrients in solution in a hydroponic garden. In high light conditions (summer), a hydroponic grower should decrease the concentration of nutrients in solution in a hydroponic garden.

Salt Build-Ups

When a plant uses a nutrient from a chemical "salt" molecule supplied in a nutrient solution, it is actually using only one part of that molecule. The remaining part of that molecule generally stays in the hydroponic system and eventually can reach damaging levels of concentration.
This process, which often happens in traditional agriculture where heavy fertilizer concentrations are applied to soil crops, is referred to as salt-build up. By testing our nutrient solution daily. we can monitor the salt levels. If the salt levels are rising. the concentration will be higher and therefore our EC reading will be higher. In our hydroponic system, it is quite easy to resolve the problems associated with salt build-up by flushing the growing medium or replacing our nutrient solution with a fresh mix.
In the soil, once salt concentrations reach toxic levels, it is difficult to correct and often makes what was once excellent farm soil unusable. The problem is exacerbated by the salts being washed and flushed into our waterways, rivers and streams where they are also toxic to fish, birds and other wildlife.

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Nutrients Requirements and Testing 5 -4

Hydroponic Garden Nutrient Monitoring:
-To ensure that your plants are being fed the proper nutrients and nutrient concentrations, it is important to monitor your nutrient solution.

On a daily basis you should test the nutrient solution and record the results

- EC (Nutrient concentrations)
- PH (acidity / alkalinity...see Lesson 4 for more information on PH)
- Temperature of nutrient solution
- Daytime room temperature
- Nighttime room temperature

It is also important to record when you replace your nutrient solution so you can easily determine when it should again be replaced.

In addition to these tests, you may also want to record the stage of plant growth, the size of your plants and any problems or significant changes.

Recording this information gives you an accurate accounting of what is happening with your plants. This data is an excellent tool for diagnosing problems, should they arise.

Advanced Nutrient Testing

Neither an EC or TDS meter can indicate precisely what nutrients make up the fertilizer solution. More complete test kits are available for this purpose. Many commercial growers test their nutrient solutions on a regular basis to ensure they are feeding exactly the mix that is intended. Regular leaf analysis is an excellent tool for determining the health of your plants. Leaf tissue samples are dried, crushed and analyzed to determine the exact nutrient content.

Most of the more complex kits will test nitrogen, potassium, phosphorous and sulfur. Commercial labs offer more precise results. In the event of a combination of nutrient deficiencies, the symptoms of one problem may mask the symptoms of another. A leaf tissue analysis may be the only way to determine what is wrong with your plants.

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Nutrients Requirements and Testing 5 -5

Month: *July* **Example of Data for Hydroponic Tomato Garden**

Date	EC	pH	Sol. Temp	Day Temp	Night Temp	Growth Stage	Size	Comments
1	*1800*	*6.0*	*74 F*	*76 F*	*70 F*	*Seed*	-	*Planted seeds*
2	*1800*	*6.0*	*74 F*	*76 F*	*70 F*	*Seed*	-	
3	*1800*	*6.0*	*74 F*	*78 F*	*70 F*	*Seed*	-	
4	*1800*	*6.0*	*74 F*	*78 F*	*70 F*	*Seed*	*0.0"*	*Seeds Germinated*
5	*2000*	*6.0*	*70 F*	*78 F*	*68 F*	*Seedling*	*0.5"*	*Leaves emerge*
6	*2050*	*6.0*	*70 F*	*78 F*	*68 F*	*Seedling*	*0.9"*	
7	*2100*	*6.0*	*70 F*	*79 F*	*67 F*	*Seedling*	*1.0"*	
8	*2150*	*6.0*	*70 F*	*78 F*	*68 F*	*Seedling*	*1.5"*	
9	*2200*	*6.0*	*70 F*	*79 F*	*69 F*	*Seedling*	*2.0"*	*2nd leaves*

								appear
10	2400	6.0	70 F	77 F	68 F	Seedling	2.3"	Replace nutrient solution
11	2400	6.0	70 F	80 F	67 F	Seedling	2.6"	
12	2450	6.0	70 F	79 F	66 F	Seedling	3.0"	
13	2450	6.0	70 F	80 F	68 F	Seedling	3.5"	
14	2500	6.0	70 F	80 F	69 F	Seedling	4.0"	Rapid growth
15	2500	6.0	70 F	80 F	67 F	Seedling	4.5"	
16	2500	6.0	70 F	79 F	68 F	Seedling	5.0"	Yellowing leaves
17	2500	6.0	70 F	77 F	70 F	Seedling	5.5"	
18	2400	6.0	70 F	80 F	69 F	Vegetative	6.0"	Replace nutrient solution
19	2400	6.0	70 F	78 F	69 F	Vegetative	6.8"	Yellowing gone
20	2450	6.0	70 F	80 F	68 F	Vegetative	7.6"	
21	2450	6.0	70 F	79 F	69 F	Vegetative	8.0"	
22	2500	6.0	70 F	77 F	67 F	Vegetative	8.8"	Rapid growth
23	2500	6.1	70 F	80 F	68 F	Vegetative	9.6"	
24	2500	6.1	70 F	79 F	70 F	Vegetative	10.2"	

25	2500	6.1	70 F	80 F	69 F	Vegetative	11.0"	
26	2500	6.0	70 F	79 F	69 F	Vegetative	11.6"	
27	2600	6.0	70 F	77 F	68 F	Vegetative	12.0"	Replace nutrient solution
28	2600	6.0	70 F	80 F	69 F	Fruiting	12.5"	buds appear
29	2600	6.1	70 F	79 F	67 F	Fruiting	13.0"	
30	2650	6.1	70 F	80 F	68 F	Fruiting	13.5"	
31	2700	6.1	70 F	79 F	70 F	Fruiting	14.0"	First flower opens

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Nutrients Requirements and Testing 5 -6

Record of Data for Hydroponic Garden

Date	EC	p H	Temperature	Growth Stage	Size	Comments
1						
2						
3						
4						
5						
6						
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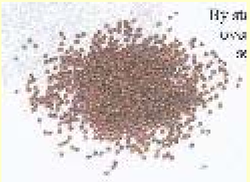
Seed Germination 6 -1

Lesson Six -Seed Germination
Planting Your Garden

When your hydroponic system is built, your pumps and timers have been tested and are functioning properly and the nutrient solutions are mixed and tested, you are ready to plant your garden.

Plants that have been raised in soil can be transplanted in a hydroponic garden if the roots are thoroughly rinsed of all soil and organic material but there is always a risk of introducing pests and disease from the nursery where the plants were propagated. There is also a strong possibility that the plants have been overcrowded, over or under watered and generally stressed.



Growrocks

By starting your plants from seed, you have the most control over the initial development of your crop. As a general rule, seeds are free of pests and disease. If you start your seeds in a hydroponic system, there is no transplant stress or shock and minimal chance of disease.

A seed needs moisture and warm temperatures to germinate, which can be provided in your hydroponic garden, or in a system designed for propagation.

Direct seeding into the hydroponic garden is a common method of propagation. Direct seeding works well in perlite, rockwool or any other medium that is fine enough not to loose the seed in. It is important to thoroughly moisten your growing medium prior to seeding.

To seed directly into perlite (or a similar medium) sprinkle the seeds on the moistened perlite and cover with a thin layer of perlite to keep the seeds from drying out. Follow the directions on the seed packet for planting depth.

Rockwool is most often used in the form of cubes for seed propagation. To plant seeds in rockwool, soak the cube in water or nutrient solution and drop the seed into the hole in the center of the rockwool cube. Many growers seed into rockwool cubes and, when the seedling develops, move the whole cube with the plant in it, into the hydroponic garden. A seedling in a rockwool cube can easily be transplanted into an NFT, ebb and flow or drip system.

Lettuce plant emerging from a rockwool cube.

Once seeded the growing medium will need to be flushed on a regular basis to keep it moist. You can initially use water for germination, right up to the point that the seed coat cracks open and the radical root is exposed. At that point you have a seedling rather than a seed, which will need water, nutrients, light and warmth. The frequency of flushing your growing medium depends on the type of medium you choose. If you are using perlite or rockwool, it will probably need to be flushed every 2 or 3 hours. The medium and the seeds need to be moist.

Controlling temperature is important for good seed germination. Some growers will start their seeds in an incubator, propagation table or similar device to maintain the ideal temperature throughout the germination process. If proper temperatures are not maintained, germination will be delayed or may not happen at all. If you are using an incubator or propagation table, you can seed directly into the growing medium.

When you plant seed for your hydroponic garden, you should over seed by 25 % -50 %. Once your seeds have developed into seedlings, you can select the strongest plants and keep them. The weaker plants can be removed by pinching the plant off at the base. Pulling the plant out will disturb the roots of the plant that you are keeping.

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Nutrients Requirements and Testing 6 -2

The Germination Process:
(see diagram on page 6-3)

The initial stages of plant growth happen within the seed coat.
As the seed absorbs water, growth begins with cell enlargement. In the presence of water, the stored reserves within the seed are converted chemically to substances that can be readily used in the growing process.

Once the seed coat breaks and the radical root comes out, the seedling will need to draw moisture and nutrition from the medium surrounding it.

Several days after the root has emerged, the shoot begins to grow. In the presence of light, the seed leaves (cotyledons) open. The opening of the first foliage leaves will follow.

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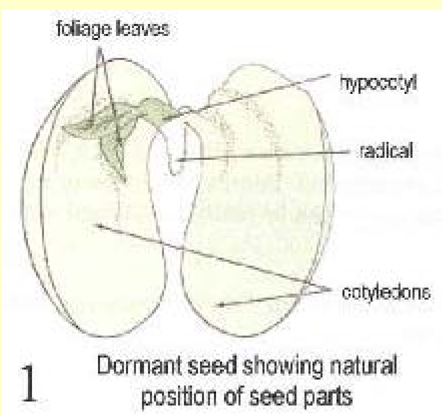
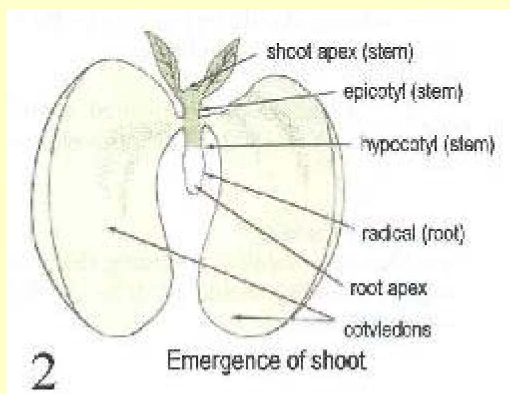
LESSON SIX

Seed Germination 6 -3

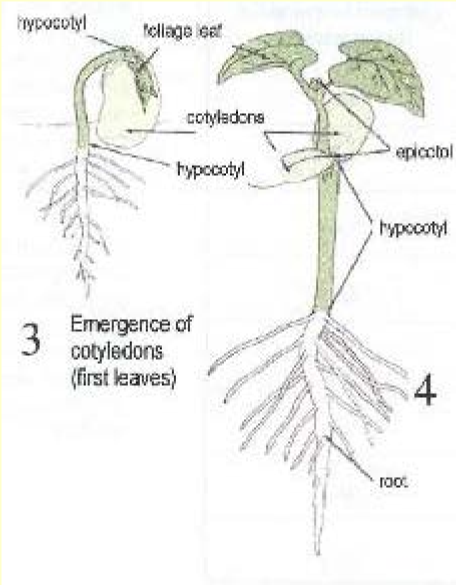
Germination Process

Sample of a Bean Seed





Seeding with first foliage leaves



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Seed Germination 6 - 4

Germination Requirements:

Moisture:
Saturate your growing medium with water or nutrient solution with a pH of 5.5 - 6.5. Be sure to keep the growing medium moist throughout germination. Ideally, the water or nutrient solution should be kept at 75 - 80 F. This temperature can be easily maintained with a submersible aquarium heater.
Once your plants have germinated, a nutrient solution with a pH of 5.5 - 6.5 and a nutrient concentration of 1800 - 2000 umhos/cm should be fed.

Relative humidity:
The higher the relative humidity, the greater the absorption of water by the seed. Ideally , relative humidity should be 70 % -80 % in the air around the media and near 100 % right around the seed.

Ideal temperatures: Bottom heat is advantageous for propagation. Heated propagation mats are made for this purpose and are often incorporated into incubation chambers and propagation tables.

Providing the ideal ambient temperature for your seeds will encourage quick germination. The chart below shows optimum germination temperatures for a variety of plants.

Crop	Optimum temperature for germination

Carrots	86 F
Cucumbers	76 F
Lettuce	76F
Melons	90F
Parsley	77 F
Peas	76 F
Radishes	86 F
Tomatoes	78

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Seed Germination 6 -5

Light
(see Lesson 7 for more information on lighting):
The first few days of seed germination (the time prior to the radical root emerging) can take place in the dark. After that time, light must be provided. If proper light is not provided, a plant will grow tall and spindly as it reaches for the light. This is often referred to as "stretching." Young plants will quickly do this. For seedling growth, having at least 500 foot candles of light is required. This can be either natural or artificial light. If artificial light is used, set a timer that turns the light on for 16 hours and off for 8 hours of each day. Plants do need darkness as part of their daily cycle, so do not leave the light on all of the time.

Choosing What Plants To Grow

When choosing the plants you will grow in your hydroponic garden, you should choose plants that have similar needs to grow together. For instance, a tomato and cucumber plant have similar needs in temperature, light and nutrient requirements. Lettuce and basil also have like needs.
Since your garden can hold a limited number of plants, be sure to plan what you will grow prior to planting. Schedule regular seeding for plants like lettuce and radishes for a continuous harvest.

Basil:
Basil is a fast growing, hardy herb that is an excellent choice for a hydroponic garden.
Once a basil plant is 12 -18 inches tall, cuttings can be taken. Remove any flowers or buds to encourage continuous leaf production. A basil plant will produce fresh growth for 3 -4 months and then should be removed from the system and replaced with a new plant.

Like needs: lettuce, spinach
Days to germinate: 6 -10

Beans:
Beans do well in a hydroponic garden. They grow rapidly and produce high yields. Beans will grow well in an Ebb and Flow system with a loose growing medium such as perlite or expanded clay pebbles.

If climbing beans are planted, you will need a trellis for support. Beans will generally produce in about 6-8 weeks, with total time in the garden about 3-4 months.

Like needs: peas
Days to germinate: 3 -8

Broccoli
Broccoli, like cabbage or cauliflower, likes cooler temperatures. If these are crops you want to grow, they should be grown together in an area where cooler temperatures can be maintained. Broccoli is slow to germinate and develop. Time from seed to harvest is about 4 months.

Like Needs: cabbage, cauliflower

Carrots:
Carrots, and other root crops will do well in a hydroponic garden as long as they have a large enough grow bed to mature and fully de-velop. A loose growing medium, like perlite, works best for root crops.

Carrots will be ready to harvest in about 2-1/2 -3 months.

Like needs: radishes, beets, leeks
Days to germinate: 6 -10

Cucumbers:
Their rapid growth and high productivity make cucumbers an ex-cellent choice for a hydroponic garden. The European seedless varieties are great tasting and easy to grow. These varieties will produce cucumbers at about 6 weeks and continue to grow up to 6 months. Being along term crop, cucumbers will do best in a drip system with perlite or rockwool as the growing medium.

Pick the cucumbers regularly to encourage continuous production.

Plant support will be needed for cucumber plants. The cucumber plant will be quite large so provide adequate space if you choose to grow them.

Like needs: tomatoes, peppers
Days to germinate: 3 -5

Lettuce:
Lettuce and leaf crops do very well in a hydroponic garden. Leaf lettuce generally will do better than head lettuce. Lettuce will grow best in an NFT system, but will also grow in an ebb and flow or drip system.

Most lettuce varieties will be ready for harvest in 35- 45 days.

When harvesting, you can remove just the leaves you need or you can harvest the whole plant. If you are harvesting the whole plant, remove the root ball with the plant and refrigerate to store.

Seed lettuce every few days for a continuous supply.

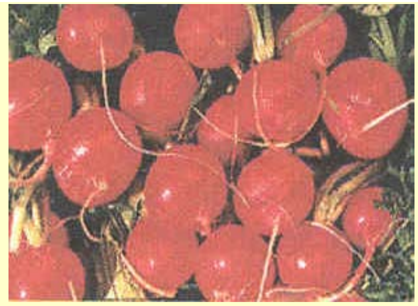
Like needs: basil, leaf crops, spinach
Days to germinate: 4 -8

Peppers
Any kind of pepper, hot or sweet, will do well in hydroponics. The only draw back is that it may take up to 4 months to harvest. The best growing system for peppers is a drip system. They will also do well in an ebb and flow system.

There are many varieties of peppers available in a wide range of colors and flavors.

Like needs: tomatoes, cucumbers
Days to germinate: 10 -14

Radishes:
Radishes will do well in hydroponics as long as they have a grow bed deep enough to accommodate their growth.



Radishes germi- nate and grow very quickly. Most radish varieties will mature in 30 -40 days. Continuous planting will give you a steady supply.
Radishes will do well in an ebb and flow or drip system with perlite
or expanded clay pebbles as the growing medium.

Like needs: carrots, beets, leeks
Days to germinate: 2 -5

Spinach:
Spinach grows well in a hydroponic garden. An NFT or ebb and flow
system will both produce good results.

Spinach is slower to germinate and grow than lettuce, with harvest at
approximately 50 -60 days.

Spinach leaves can be harvested as you need them or, like lettuce, the
whole plant with the root ball intact can be harvested. Seed often for a
continuous supply.

Like needs: lettuce, basil
Days to germinate: 6 -12

Strawberries:
Strawberries will grow quite well in a hydroponic garden. Most of-
ten, you will find strawberry shoots rather than seeds. These shoots
can be transplanted into your garden but be sure they are free of pests
and disease and then wash the roots thoroughly to remove all soil and
organic debris.

Tomatoes:
Tomatoes are the most popular commercial hydroponic crop.
Most commercial growers grow full size, indeterminate varieties. These varieties will bear fruit in about 100 days and continue to produce up to a year. There are miniature tomato varieties available that are perfect for a smaller hydroponic garden.

A drip system is the best method of growing tomatoes in a

hy-
droponic garden but they will also grow in other systems.

If you are growing tomatoes indoors, you may need to pollinate the individual flowers for fruit set to occur. This can be achieved by vibrating the flower or flower truss. As a tomato plant develops, plant support will be needed.

Like needs: cucumbers, peppers
Days to germinate: 3 -6

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Photosynthesis and Light

Lesson Seven -Light

Transpiration and Photosynthesis
Plants require a constant supply of energy to grow and this energy comes from light. In nature, plants receive light from the sun. In a classroom, you may need to add artificial light so your plants have an adequate amount of light to grow.

There are various types of artificial lights that provide differing light spectrums. Before learning about these artificial lights, it is important to understand how plants use light in the growth process.

Transpiration and photosynthesis are the two major processes that are carried out by green plants that use energy from the sun. Both of these processes use large amounts of light energy but. only in photosynthesis is a significant amount of energy from light actually stored for future use. Light influences other processes such as flowering, seed germination, certain growth stages and pigment production but, in these cases, only very small amounts of energy from light are used.

During the transpiration process, plants draw in carbon dioxide from the air through their pores and water from their roots and give off oxygen and water vapor. Energy from the sun evaporates water from the plant cell walls. Although this results in a movement of water in the plant tissue (xylem). this energy is neither stored nor used to bring about vital reactions involved in the synthesis of foods, in assimilation, growth or reproduction.

In photosynthesis, which literally means "putting together (synthesis) by means of light (photo)," water is drawn up through the stem from the roots and into the leaf tissue where the chloroplasts, containing chlorophyll (a green pigment) can be found. There the water encounters carbon dioxide which entered the leaf from the air through minute breathing pores (stomata) located abundantly on the underside of the leaves. The stomata also permits the outflow of water vapor and oxygen. The light, carbon dioxide and water produce carbohydrates which are stored in the plant and later released as energy for other vital plant functions.

Energy stored as chemical energy in foods (carbohydrates, fats, proteins) is continually released in living cells during the process of respiration. Basica1ly, photosynthesis stores energy and respiration releases it. enabling cells to perform the work of living. By releasing energy, respiration provides the energy needed for all other plant functions.
All animals ultimately depend on photosynthesis because it is the method by which all basic food is created.

Light Spectrums
White light, as it comes from the sun, is composed of waves of red light, through successively shorter waves to violet light. The band of colors that compose the visible spectrum of light (that which we can see) include, starting with the longest rays, red, orange, yellow, green, blue, indigo and violet. The visible spectrum represents only a part of the radiant energy that comes from the sun and only a part of the visible spectrum is effective in photosynthesis.

Wavelengths exist that we our unable to perceive with our eyes. Beyond the red rays are still longer rays called infrared and beyond the violet rays are even shorter rays called the ultraviolet.
The fact that chlorophyll is green to the eye is evidence that some of the blue and red wavelengths of white light are absorbed, leaving proportionally more green to be transmitted, reflected and seen.

Much of the red, blue, indigo and violet wavelengths are absorbed and used in photosynthesis while part of the red and most of the yellow, orange and green are barely used in photosynthesis.

Signs of Light Deficiencies:

- plants will stretch and reach toward the light source
- stem elongation
- plant deformities
- no fruit set

Artificial Lighting
If your hydroponic garden is in direct sunlight, the plants should receive adequate amounts of light and absorb the spectrums they need.

In a greenhouse setting, supplemental light is sometimes used to extend the hours of light a plant receives during low light conditions (cloudy weather or short days), and to extend the growing season of a plant. If you are growing in an area with some, but limited sunlight, such as a windowsill, supplemental lighting will be needed.

Any supplemental light is beneficial to increase plant growth and production. The higher the intensity and the broader the spectrum, the greater the benefit.

You can grow in a completely enclosed space with no natural light if you provide all artificial light but there are several drawbacks including the cost of the lights and the energy to run them is high, there may be a compromise of the plants needs if the artificial lighting does not provide the complete light spectrum the plant needs and artificial lighting will not exactly duplicate the spectrum of light the sun provides.

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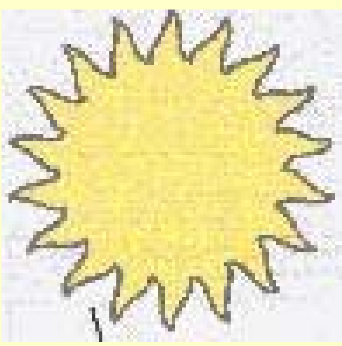
LESSON SEVEN

Photosynthesis and Light 7-2



Photosynthesis and Transpiration

Energy (light) comes from the sun

Photosynthesis:
Leaves make food (carbohydrates), water and oxygen from sunlight, carbon dioxide and water.

Transpiration:
Leaves draw in carbon dioxide from air through pores and give

Plants draw water from the soil or growing off water vapor and oxygen.

medium.

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Photosynthesis and Light 7-3

Light Spectrums

Wavelength	Visible to the human eye	Used in pho-tosynthesis	Used in flowering
Infrared (longest rays)			
Red	X	X	X
Orange	X		X
Yellow	X		X
Green	X		X

Blue	X	X	
Indigo	X	X	
Violet	X	X	
Ultraviolet (shortest rays)			

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LESSON SEVEN
Photosynthesis and Light 7-4

Plant Light Needs:
Plants have differing needs for light and, as a general rule, most fruiting crops need more light when they are in a fruiting stage than when they are in a vegetative stage.

The chart below shows a variety of crops and their individual light needs.

Crop	Light Needs
Beans	Medium - High
Beets	Low
Broccoli	Medium - High
Cabbage	Low -Medium
Carrots	Low
Cauliflower	Medium -High
Cucumber	High
Lettuce	Low
Melons	High
Peas	Medium - High
Peppers	High
Radishes	Low
Onions	Medium - High
Spinach	Low
Tomatoes	High

Various crop Light Needs

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Photosynthesis and Light 7-5

Lamp Placement:
When lighting your plants, the proximity of the lamp to your plants is directly related to the intensity of the light provided. The closer the lamp, the more intense the light. When you raise your lamp, the intensity is lessened. It is important not to have your lamp so close that it burns the plant leaves.

Increased light coverage can be achieved by installing a light mover that will rotate your light. You can also use reflective paint or reflective surfaces (aluminum foil, for instance) surrounding the growing area to increase light.

Types of Lights for Plant Growth
HID (High Intensity Discharge) lights are the common choice for supplemental lighting in a large space such as a greenhouse. They are the most efficient and very intense. Metal halide, mercury vapor and high pressure sodium lights are examples of high intensity discharge lights.

If you are growing in an area that has some natural light, such as in a windowsill, you can probably light it with a less intense light. Fluorescent tubes will likely provide the additional light that you need.

Fluorescent lights will also be adequate for propagation of seedlings, plant cuttings and some low-light house plants.

In a grow room without noticeable natural light, HID's are necessary to provide ample light for plant production. High Intensity Discharge lights can create an excessive amount of heat.
When using HID's, ventilation and cooling may be necessary. Vented reflector hoods are available for this purpose. Also keep in mind that HID's require high amounts of electricity and are more costly to run than

most other types of lights.

Incandescent Light:
Although some supplemental light is better than none, incandescent light offers the lowest level of intensity and is generally better used as a room light than a plant light.

Specialty incandescent grow bulbs are available and will provide a better light spectrum than a standard incandescent bulb but the intensity is still limited.

Standard incandescent bulbs are high in the red spectrum but low in the blue spectrum which most plants need for vegetative growth.

Incandescent bulbs are inexpensive to initially buy but they are generally not efficient or effective for plant growth.

Fluorescent Light:
Fluorescent tubes offer a broader color spectrum and are available in a variety of kinds including bright white. cool white. warm white. plant bulbs. daylight and full spectrum. The combination of warm and cool white offer a broad light spectrum.

Fluorescent bulbs are relatively inexpensive, long-lasting and provide even, cool lighting.

The down-side to fluorescent lights is that they are low in intensity and need to be very close to the plants to be effective. Seedlings, cuttings and most house plants will benefit from fluorescent lighting.

Metal Halide Light:
Metal halide lights offer a broad spectrum with ample blue light for vegetative growth. The metal halides are more efficient than Mercury Vapor lights. which at one time. were the primary source of HID light.

Metal halides are one of the best light sources for plant growth and, if you were using only one type of light, metal halide would be the best choice.

High Pressure Sodium Light:
High pressure sodium lights are very efficient. They are long lasting and strong in the yellow- red spectrums. Their only disadvantage is that they aren't quite strong enough in the blue spectrum for vegetative development.

The high pressure sodium lights are a good choice for flowering plants. The combination of metal halide and high pressure sodium offers the broadest light spectrum and must be used in situations where no natural light is found.

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Introduction to Botany 8-1

What is Botany?

Botany is the study of plants. It is divided into many areas including:

- *plant taxonomy* (identifying, describing and classifying plants)
- *plant geography* (the location of certain plants)
- *ecology* (studies the relationship between plants and the environment)
- *paleobotany* (the study of ancient plants)
- *phytopathology* (the study of plant disease)
- *economic botany* (how plants can be used as products)
- *plant morphology* (the structure of plants)
- *plant physiology* (the function of plant parts)
- *plant crytology* (the study of plant cells and their parts)
- *plant anatomy and histology* (the internal structure of plants)

As you can see, botany is a very broad subject and one that we can only scratch the surface of in this lesson where our focus will be on an introduction to *plant morphology* and *plant physiology.* In Lesson Ten you are introduced to *economic botany.*

What makes a Plant "a Plant"?
In the five-kingdom classification system, plants are considered

multi-cellular (having multiple cells) and eukaryotic (having a
membrane around the nucleus of each cell). In addition, plants
have light-absorbing molecules (chlorophyll) and a number of
cartenoid pigments. Plants store food in the form of carbohy-
drates and their cell walls are made mostly of cellulose.
Plants are necessary for the continuation of life on Earth be-
cause they are an integral part of the food chain, supplying both
energy and oxygen for more complex life forms. Plants are
found everywhere except the polar zones, the highest moun-
tains, the deepest oceans and the driest parts of the deserts.
It is estimated that up to 90% of the living mass on Earth is
made up of plants. There are an estimated 400,000 species of
plants with Columbia, Equador and Peru having more plant
species than any other collection of countries in the world.

A *variety* of *plants*

The parts of a flowering plant include:

The Stem
The stem produces and supports new leaves, branches and flowers and keeps these parts in effective positions to receive light, water and warmth. The stem's main function is to transport water and nutrients to and from the roots. In some cases it may also contribute to the reproduction of the plant, store food or help in photosynthesis.

The Root
The root of a plant is what anchors the plant in the soil and absorbs nutrients and water. In hydroponics, the root mainly serves only to absorb the nutrients and water we feed them. Roots range from a single large root, the tap root, to a mass of smaller, similar sized roots. The roots penetrate the soil or growing medium by cell division and elongation of the cells just behind the tip.
In a hydroponic growing system, the plant's root system will be much smaller than if it were grown in soil. Since the purpose of the roots are to seek out and absorb the nutrients and water and a hydroponic solution provides exactly what the roots are looking for, they do not need to develop an extensive root system.

The Leaf
As we learned in Lesson Seven, leaves are the plant's means of intercepting light, obtaining and storing water and food, exchanging gases and providing a site for photosynthesis.

The Flower

The flower of a flowering plant is the sexual reproduction unit that produces and houses the sex cells (gametes). Flowers also attract pollinators (e.g. insects and birds) that carry pollen from the stamen and fertilize other plants.

The Fruit

The fruit aids in the dispersion of the plant's seeds. After fertilization, the ovary begins to develop into a fruit, the ovules into seeds. The seeds are carried off and will, if conditions are right, eventually germinate and start a new plant. Seeds are dispersed in several different ways: Light seeds, such as dandelions, can be carried by the wind. Birds are attracted to some fruits and, after eating the fruit, leave seeds in their droppings. Some seeds are barbed and easily stick to unsuspecting passersby (usually animals). Eventually, the seed is scratched off or falls off. Some seeds will drop from the plant in a high wind or when shaken.

Fruit

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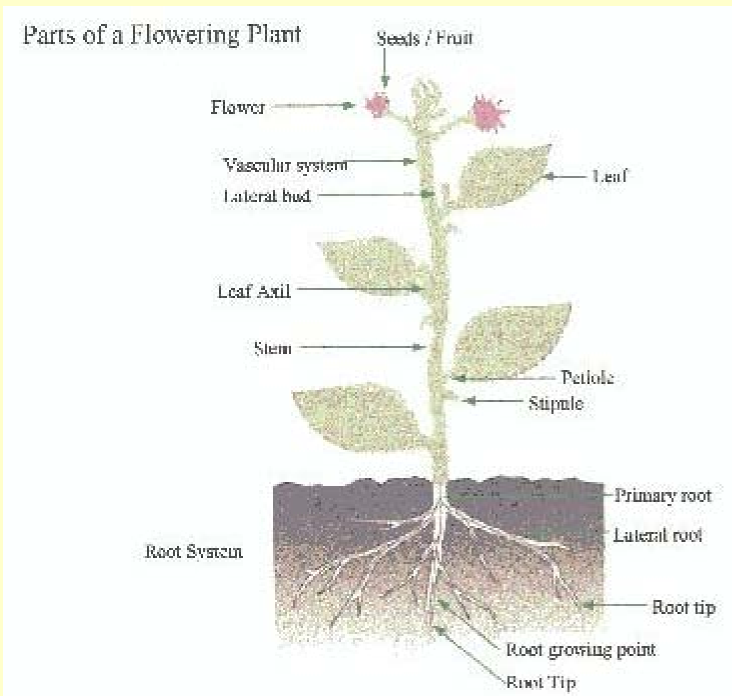

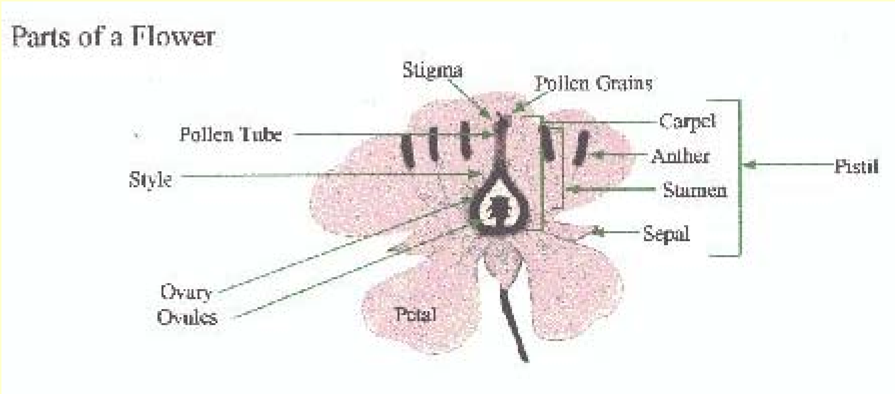

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Introduction to Botany 8-3

Categories of Plants

Plants fall into different categories, determined by the plant's life cycle in the environment.

Type	**Life Cycle**
Annual	An annual plant (also known as "determinate") completes its life cycle within one growing season-from germination of a seed through growth, flowering, production of seeds and death.
Biennial	A biennial plant has a natural life cycle of two growing seasons. The seed is sown in the first year and the plant grows, usually with vegetative growth. The second year, it flowers and dies.
Perennial	A perennial plant (also known as "indeterminate") lives for a number of years and flowers each year.

There are other divisions of plants based on their hardiness.

Type	**Characteristic**
Tender	Sensitive to the cold (can be annual, biennial or perennial)
Hardy	Able to withstand frosts (can be annual, biennial or perennial)

Plant Reproduction:

Plants reproduce by sexual or asexual reproduction or both depending on the species. One of the most important factors that aid in plant growth and reproduction is the availability of nitrogen (N_2).

Sexual Reproduction
Seeds are the focus of sexual reproduction in plants. As a seeded plant grows, it holds an egg within and when the plant matures, the egg is fertilized by pollen from itself or another plant. Fertilization from other plants usually takes place by the transfer of pollen grains which can be carried by the wind, insects, bees, birds or animals. The fertilized egg (zygote) remains in the plant and eventually becomes a seed ready to produce another plant.

Asexual Reproduction
Asexual plant reproduction requires only one organism. There is no change in the chromosome number if a new plant is separated from the parent plant. Single cell division in asexual reproduction does not change the chromosome number. The new plants have the same genetic structure as the parents.
Asexual reproduction includes plants that grow from bulbs (such as tulips), feelers (such as crabgrass) and rhizomes (underground stems). Branches grafted to trees (such as certain types of oranges and grapes) can also be classified as asexual reproduction. Single celled plants (such as algae) also reproduce asexually by ordinary cell division.

Plant Growth Stages for Fruiting Plants:

All flowering plants go through the basic growth stages: seedling, vegetative, early fruiting and mature fruiting. As the plant passes from one phase to another, there are not clear demarcations between the phases. In fact, there is usually overlapping from one to the next.

Seedling
When a seed has germinated and the cotyledons (first leaves) emerge, the shoot begins to grow and the plant enters the seedling stage. During this time, providing exactly the right environ- mental conditions and nutrient diet is critical to the well-being of your plant. A healthy seed- ling will be deep in color and will quickly develop new leaves. The stem will grow strong to support the weight of the plant.

An unhealthy seedling will be pale in color and, often, the stem will be weak or break off all together.

The growing conditions under which seedlings are grown affects the fruiting and health of the crop for its entire life.

In a hydroponic system, the seedlings are usually fed a weaker nutrient solution than a mature plant.

Vegetative
The vegetative stage begins when your plants are quickly developing their leafy mass and often continues throughout the plant's life. In fruiting plants, it is important to build a strong plant prior to the development of the first flowers.

The nutrient solution that is being fed to the plants is usually increased to a stronger solution with a higher percentage of nitrogen in the vegetative stage. The vegetative stage is quite demanding of Nitrogen.

Early Fruiting
The early fruiting stage begins when the first buds appear on a plant. At this point, specifically with tomato plants, the nutrient concentration is again increased to a stronger solution but the percentage of Nitrogen is

decreased.

Mature Fruiting
The mature fruiting stage begins when your fruit begins to ripen. Depending upon the variety of plant and whether or not it is determinate or indeterminate, this stage can last from one month to several years. With an indeterminate variety (which is what most commercial hydroponic tomato growers grow) it is important to balance the vegetative growth with the fruiting. Too much vegetative growth will halt fruiting and produce an unruly plant. Too heavy of a fruit load will result in the plant halting new flower production until the fruit load in lessened resulting in uneven harvesting.

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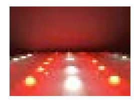

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Biological Pest Control 9-1

Lesson Nine - Biological Pest Control

Many gardeners and consumers are concerned with the quality, purity and safety of the food they eat. With soils becoming tainted and water sources polluted, it is a valid concern. In the farming industry, use of pesticides and herbicides has grown for years as farmers have attempted to control the pests and weeds that challenge their crops.

With consumers demanding safer produce, there has recently been an active movement away from excessive pesticide use. One way to achieve this is by the use of Biological pest controls rather than chemical pest controls. Biological controls consist of insects, mites and micro-organisms which, as natural enemies, keep pests under control.

Many commercial hydroponic growers who produce their crops within a controlled environment greenhouse exclusively use biological controls for problem pests. When bringing biological controls or beneficial insects into the greenhouse a natural balance can be achieved. It is possible to control pests in an open field with biological means but it is not as effective as within a greenhouse or other closed environment.

Virtually all insects have a predator or enemy and that is what makes biological control work. There are insectaries (facilities that raise insects) throughout the US and Worldwide that breed and sell beneficial insects. Beneficials are shipped as eggs, larvae or adults and are usually sent overnight to the user who quickly distributes them to the problem areas.

In the world of beneficial insects, there are predators and

parasites.
Predators will actually consume the pest insect. A lacewing is a good
example of a predator. Lacewings are welcomed in most gardens be-
cause they are know for their voracious appetite and broad diet of various insects.

Leaf Miner
Pest Insect

A parasite is an insect that lays its eggs within the egg sack of another insect, displacing or consuming the eggs that were there. The Larvae that emerge from the egg sack are those of the parasite, not it's victim.

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Biological Pest Control 9-2

Garden Pests and Their Biological Controls

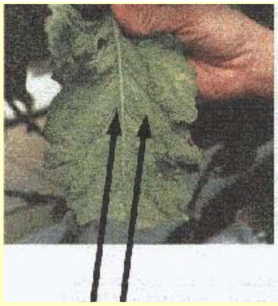
Pest:

Whitefly:

Whitefly are an extreme problem for greenhouse growers, field and orchard crop farmers and home gardeners. The *whitefly* sucks large quantities of sap from the plant and secretes the sugars as honeydew. This makes the leaves sticky and susceptible to fungal growth and rot. In a ser-

Whitefly

ious infestation, the fungus and rot associated with the honeydew can kill an entire crop in a matter of weeks. In addition, whitefly can pose a great threat to plant health because they are able to transmit many plant viruses.



Whitefly eggs on the underside of a tomato leaf

A *whitefly* looks like a small white moth, 1/8" in length. They rest on plant leaves and will quickly fly away when disturbed.

Whitefly lie their eggs on the under side of a leaf. Shiny, sticky leaves are signs of *whitefly* presence.

Biological Control:

Encarcia Formosa.

This tiny parasitic wasp lays its eggs in the larvae of
the whitefly. Parasitized larvae turn black and are eas-
ily recognized. Adult *EncarsiaFormosa* also feed on
honeydew and the body fluids of whitefly larvae.

Encarcia Formosa

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Biological Pest Control 9-3

Pest:

Thrips:

Thrips are found in crops all over the world. Crops are attacked by a number of species of these small winged in-sects. Larvae and adult insects feed on all above-ground parts of the plant and, as a result, the tissue dies. Loss of chlorophyll reduces yield. Serious attacks may result in desiccation of leaves and damage to flowers and fruits. *Thrips* can also transmit plant diseases.

Thrip

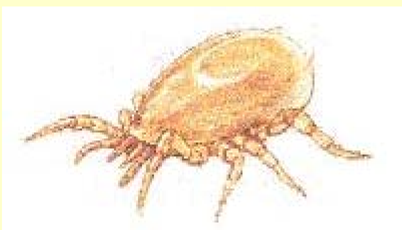
Due to their small size, the damage *thrips* do is usually spotted before the *thrips* are noticed. Damage appears as small yellow speckles on the leaves later followed by a silvery sheen on leaf surfaces. The *thrips* feed by scraping at tender leaves, with most damage occurring on new growth. They are only 1/12" long, but can move very quickly. Adults look similar

Thrip damage on plant leaf

to a
small worm with wings. *Thrips* can also carry and
transmit
plant disease.

Biological Control:

Amblyseius cucumeris and *Orius laevigatus*
Amblyseius cucumeris is an effective predator of young thrip larvae. *Orius laevigatus,* another predator, is often applied in conjunction with *Amblyseius* because they kill adults and larger larval stages of *thrips.*



Amblyseius cucumeris

Onus laevigatus

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Biological Pest Control 9-4

Pest:

Aphids

Aphids inflict serious damage in various crops and
their reproductive capacity is enormous. The damage
they cause is due to secreted honeydew resulting in
contamination of fruit. *Aphids* are also notorious for
carrymg vlruses.

Green aphids

Aphids are slow moving insects, inhabiting the undersides of leaves. They establish dense colonies of tiny (1/32" -1/8"), soft bodied, pear shaped insects that are light green, pink, yellow, brown or black in color.

Biological Control:

Aphidius colemani and Aphidoletes aphidimyza

The parasitic wasp *Aphidius colemani* is particularly effective against some species of aphids. Parasitised *aphids* form characteristic white "mummies." *Aphidoletes aphidimyza is* effective on a wide range of *aphid* species and lays its eggs in aphid colonies. The orange larvae that hatch from these eggs feed voraciously on *aphids.*

Aphidius colemani

Aphidoletes aphidimyza

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Biological Pest Control 9-5

Pest:

Red Spider Mites

Red Spider Mites are a pest of nearly all horticultural crops, both in green-houses and outdoors. Their tremendous reproductive capacity means that these mites are capable of rapidly destroying plants. The larvae, nymphs and adult mites all cause damage to the plant by feeding on plant tissue.

Spider Mites

Red Spider Mites are about the size of a pin head, inhabit the undersides of plant leaves and can be seen scurrying around. Their eggs can be seen with a magnifier, scat-tered at random and ranging in color from clear to tan. With large infestations, a fine webbing can be seen covering the plant top. *Red Spider Mites* prefer lower humidity levels and normally go dormant in winter.

Biological Control:

Phytoseiulus persimilis

This predatory mite feeds on eggs, nymphs and adults of
a number of species of red spider mite. *Phytoseiulus*
persimilis responds to specific chemical cues when lo-
cating it's prey" This makes it effective in locating new
Red Spider Mite colonies.

Phytoseiulus persimilis

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Biological Pest Control 9-6

Pest:

Leaf Miners

Leaf Miners are a major problem for many crops. The larvae form
tunnels in the leaves of the plant. This may lead to desiccation and
early leaf loss. The loss of chlorophyll may result in severe reduc-
tions in yields.

Damage by Leaf Miners

Leaf Miner adults are small black and yellow flies. *Leaf Miners* eggs are inserted in leaves
and larvae feed between leaf surfaces, creat-
ing a meandering track or "mine." At high population levels, entire leaves may be cov-
ered with these tracks. Mature larvae

Leaf Miner

leave
the tracks, dropping to the ground to
pupate.
This life cycle takes only 2 weeks in warm
weather.

Biological Control

Dacnusa sibirica and *Diglyphus isaea*

These parasitic wasps lay their eggs in or near leaf miner larvae. The young parasite larvae hatch from these eggs and begin to feed on their host, internally if *Dacnusa* and externally if *Diglyphus.* Eventually a new parasite adult emerges to continue the work of its predecessors.

Dacnusa sibirica

Diglyphus isaea

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Biological Pest Control 9-1

Pest:

Beet Armyworm

The *beet armyworm* is a major pest of fresh market
tomatoes. Each larvae may damage several fruit,
leaving shallow gouges that make the fruit unmar-
ketable. Newly hatched larvae feed together near
the egg cluster and gradually disperse as they grow.
They skeletonize leaves and may leave a webbing
on the feeding site. Older larvae chew
irregular pieces from leaves and feed on
green fruit.

Beet Annyworm

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Beet armyworm eggs are laid in clusters covered with hair-like scales left by the female moth.

There may be 100 or more per cluster. Larvae are usually dull green with many fine, wavy, light colored stripes down the back and a broader stripe along each side. The adult beet army-worms are smooth skinned, without any obvious hairs.

Biological control

Hyposoter exiguae

This parasitic wasp is a natural enemy of *beet armyworms.* It also attacks tomato fruit worms and cabbage loppers. The *hypo-soter exiguae* usually kills the larvae in the third instars and gen-erally has its greatest impact early in the season.

Hyposoter exiguae

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Biological Pest Control 9-8

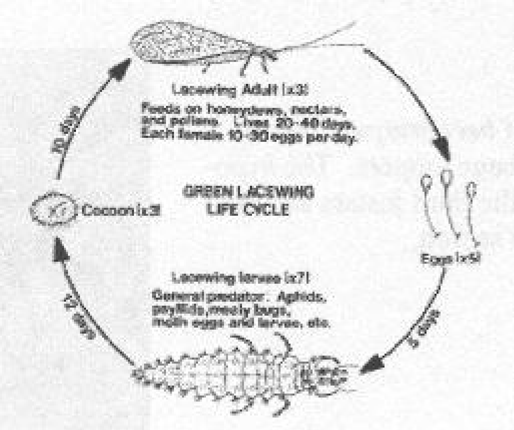
Other Beneficial Insects

Two other insects that are always considered beneficial
are ladybugs and lacewings. Both are predators, known
for their voracious appetites and broad diet of insects.
Both of these predators will help control almost every pest
insect that we have discussed with the exclusion of the
beet armyworm.

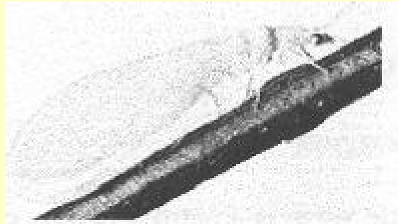
Ladybug consuming aphids

Both the ladybug and lacewing actively feed and consume problem pests in the larval stage as well as the adult stage.

Ladybugs and lacewings are a welcome addition to any garden, farm or greenhouse.



Lacewing Life Cycle


Adult Lacewing

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Biological Pest Control 9-9

Other Safe Options for Pest Control

Occasionally, additional means of control will be necessary and, fortunately, there are other safe options for pest control.

Insecticidal Soap
Insecticidal soap is an environmentally sound method of getting rid of pest insects. It is basically a soap solution that, when sprayed directly on the insect, will smother them. It does not leave a residue and crops sprayed with insecticidal soap can be harvested the same day. As a general rule, insecticidal soap will not harm most beneficial insects.

Insecticidal soap is available as a spray or in a concentrate form to be mixed with water. For best results, use softened or purified water if you are mixing it from the concentrate.

Sticky Strips
Sticky strips provide a safe method of trapping insects. The insects are attracted to the bright color of the sticky strip and, once they land, they are stuck. When the strips are full, simply discard and replace with a new ones.

Many commercial growers use sticky strips for monitoring what insects are in the greenhouse. By checking the sticky strips on a regular basis, the grower knows what insects are present and whether or not the population is growing.

Botanical Sprays

Botanical sprays are made from plants that have insecticidal qualities. These products are generally safer than chemical insecticides but, even though the are natural, they are insecticides and should only be used as a last resort.

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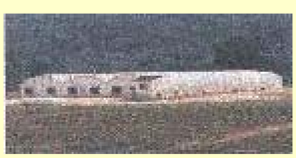
Lesson Ten

The demand for premium, healthful produce has risen dramatically over the past ten years. Consumers today want and will pay a premium price for produce that is known to be safe and free of harmful pesticides and herbicides.


Commercial hydroponic greenhouse

The combination of hydroponic technology and a controlled environment greenhouse is an ideal solution to filling this demand. With this combination, known as Soil- less/Controlled Environment Agriculture (S/CEA), a grower can produce extremely high quality produce close to the marketplace. This eliminates the cost and damage that occurs in commercial trucking of field produce.

A commercial hydroponic operation uses up to 1/20 of the water and a fraction of the space needed to produce an equivalent amount of produce in traditional agriculture.

There are hydroponic farms throughout the United States and worldwide. Most hydroponic farms in the US are family or small business operations. Several large hydroponic facilities, covering as much as 80 acres, are spread throughout the United States.

The smaller hydroponic farms usually have 1/8 -1 acre in hydroponic production while the larger facilities average 20 - 40 acres. The smaller operations generally have the advantage of offering vine ripened produce and being near the marketplace.

The premium quality of hydroponic produce is due to the controlled environment, green-house grade, pure nutrients and the lack of herbicides and pesticides.

The most popular hydroponic crop in the US is tomatoes, with
second being cucumbers, third, leaf crops and fourth, herbs,
peppers and flowers. Ironically, there is more hydroponic pro-
duce flown into the United States from Holland, Canada,
Europe and Mexico than is grown here. As more and more
hydroponic farms are established in the United States, this will
change.

Hydroponic tomato crop

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The Business of Hydroponics 10-2

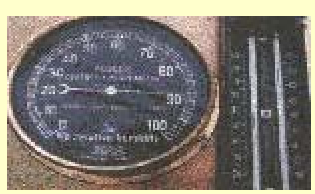
The productivity of commercial systems has improved greatly and the cost has dropped in the past few years. Commercial tomato growers who once hoped to annually pick 20 pounds per plant are now picking as much as 35- 40 pounds per plant annually. The cost of establishing a commercial hydroponic greenhouse operation is quite reasonable when considering the potential profits.

With proper training, hard work and good business sense, a grower can make their hydroponic greenhouse business a profitable venture.

The Daily Operation of a Hydroponic Greenhouse

On a day-to-day basis, most commercial hydroponic growers do testing and monitoring similar to what you have done in your hydroponic garden in the classroom. The pH and nutrient concentrations of the feed solution and that of the reservoir need to be tested and the temperature and humidity levels monitored.

An efficient grower will record all of this information. This data is helpful when assessing the overall health of the crop, diagnosing problems and ascertaining what factors may have positively or negatively affected their crop.



A grower must also ensure that the plants are getting

fed prop-
erly and on time. Depending on the stage of growth of the crop
and the amount of light available, a grower alters the concentra-
tion of the feed solution.

Hygrometer and thermometer for monitoring temperature and humidity

The most important job of a commercial grower is to be obser-
vant, meticulous and organized. When a grower is in the greenhouse, they must closely look at the plants to see if there are any changes, pests or disease that could threaten their crop. Daily observation is crucial in the prevention of large problems in the greenhouse.

Plant Culturing

In addition to the daily monitoring of a crop, there are many culturing chores that a grower per-forms to ensure the highest quality fruit and the highest quantity harvest. With along term fruiting crop, such as tomatoes or cucumbers, there is more daily culturing chores than with a short term crop, such as lettuce. With a lettuce operation, more emphasis is placed on continu-ous seeding and harvesting of the crop rather than plant culturing.

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The Business of Hydroponics 10-3

Most commercial tomato growers plant an indeterminate variety from seed. They replant their greenhouse once a year. The seeds can be propagated in a small space and, when the seedlings are several weeks old, they are moved into the greenhouse. With most varieties, the grower will begin harvesting in about 100 days and continue harvesting for 8-9 months.

In fruiting crops, there are five primary culturing jobs that need to be done every week. These jobs include:

Clipping

When the tomato plants are set out in the greenhouse, they will need to be supported. The type of support system used varies from grower to grower but most are some variation of the following. Main support wires are strung above the plant rows. From the main wires a string is hung down to each plant and then the plant is clipped to it. The tomato plants can grow as much as one foot per week so the clipping process needs to be done every week.

Plant clip and support string on a tomato plant

Sucker Pruning


Removing a sucker

When the tomato plants are four or five weeks old, suckers (also called side branches) begin to grow at every leaf axial. In the greenhouse, you groom the plant to one main stem, removing each of the side branches and leaving only the main stem and leaves. From this point on, sucker pruning will need to be done once a week.

A sucker is removed by firmly grasping the sucker and bending it one way and then back.

Cluster Pruning

To ensure an even fruit load on the plant and larger tomatoes overall, a hydroponic grower cluster prune. Cluster pruning begins when your first tomatoes have set and are approximately the size of a pea. When cluster pruning, you remove the misshapen, smallest and weakest fruit, leaving the largest to develop. Depending on the season and the current fruit load, most of beef-steak-type tomato growers prune the clusters to 3 or 4 tomatoes and most cluster-type tomato growers prune the clusters to 5-6 tomatoes per cluster. Most growers will cluster prune their tomato plants once a week.


Cluster pruning

Leaf Pruning

As a tomato plant matures, the lower leaves can be removed to encourage fresh new growth at the top of the plant. The lower leaves easily break off when pressure is applied at the base of the leaf.

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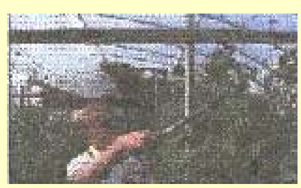
The Business of Hydroponics 10-4

Leaning and Lowering
An indeterminate tomato variety can grow to lengths of25 feet or more. To keep the growing part of the plant within reach, growers lean and lower the whole plant. When the plants are leaned and lowered, the top 6 feet, which is the producing part of the plant, is left vertical and the remaining stem is laid horizontally.

Other Greenhouse Jobs
In addition to the weekly jobs a hydroponic farmer does, there are several other processes that need to be accomplished on a regular basis.

Pollination
In an outdoor environment, the tomato flowers would be pollinated by insects and wind but, since there are limited amounts of both in the greenhouse, the grower needs to pollinate the flowers. There are polli-nating wands that a grower can use. Touching this vibrating wand to every open flower cluster will give adequate pollination.



Pollinating

Most l arge hydroponic operations bring a specialized bumble bee hive into the greenhouse and allow the bees to do the pollinating.
The bees are labor saving and more efficient than a person. Bees have virtu-

Bumble bee

ally no tolerance for pesticides so, if bees are used for pollination in a greenhouse, biological control must be the only means of insect control employed.

Most hydroponic cucumber varieties are self-pollinating so growers of cucumbers do not need to pollinate the flowers.

Harvesting and Packing

Most hydroponic greenhouse growers who are close to the marketplace will allow their tomatoes to vine-ripen. They harvest them every two or three days. Many growers of premium produce will label their product with a the brand name and brief description or the benefits of how it was grown.

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The Business of Hydroponics 10-5

Marketing

So a hydroponic grower has completed their daily testing, weekly cultur-
ing chores and grown a premium product. ..what do they do with it?
Sell it!

In most cases, the cost of growing a crop in a controlled environment is
higher than a field-grown crop. The farmer growing in a controlled envi-
ronment has maintained the ideal temperatures, humidity, light and feed
to the plants. In return, their produce should be of the highest quality
and, if marketed properly, should bring a premium price.

A hydroponic grower should be sure to emphasize what makes their pro-
duce special and what makes it taste so good.

Points that a hydroponic farmer might promote are:

- vine ripened

- tastes, looks and smells great
- grown in a controlled environment
- hand picked and packed
- herbicide free
- pesticide free
- available most of the year
- higher nutritional value

Growers can sell their fresh produce in a number of ways, some of which include:

Direct to grocery stores
When you sell directly to grocery stores, you have the most control over how your produce is transported and handled. The disadvantage is that you need the expertise and time to effectively establish markets and then deliver your produce on a timely basis.

Sell to a **produce broker**
If you do not have the expertise or time to market your produce you may consider having a produce broker or distributor market your produce for you. A broker will usually charge 15 -20 % of the gross sales for their service. Broker marketing is convenient, but you will earn less and lose control over the handling and transportation of your produce.

Market through a **co-op or grower network**
A co-op is a compromise between you doing the marketing and having someone else do it for you. If there are several growers in an area, they may be able to share the responsibilities of marketing and delivery.

Roadside stand or farmer's market
A farmer's market or roadside stand allows you to sell directly to the customer. Since you are selling retail with this means of marketing, you will probably have the highest profits. The disadvantage is that you not only have to bring your produce to the market, you have to stand there and sell it. For some growers this is an ideal means of selling their produce. For others, it isn't worth the extra time involved.

A commercial grower of hydroponic produce must always remember that they are selling a premium product and, as long as the quality is there, the market will follow.

This Educator's Guide contains the information needed to teach this unit. Each lesson includes a lesson overview, objectives, estimated time, out line, homework/review and an activity complete with required equipment, instructions and goals.

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