Snake

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Snakes are elongated, legless, carnivorous reptiles of the suborder **Serpentes**[2] that can be distinguished from legless lizards by their lack of eyelids and external ears. Like all squamates, snakes are ectothermic, amniote vertebrates covered in overlapping scales. Many species of snakes have skulls with several more joints than their lizard ancestors, enabling them to swallow prey much larger than their heads with their highly mobile jaws. To accommodate their narrow bodies, snakes' paired organs (such as kidneys) appear one in front of the other instead of side by side, and most have only one functional lung. Some species retain a pelvic girdle with a pair of vestigial claws on either side of the cloaca.

Living snakes are found on every continent except Antarctica, and on most smaller land masses; exceptions include some large islands, such as Ireland, Iceland, Greenland, the Hawaiian archipelago, and the islands of New Zealand, and many small islands of the Atlantic and central Pacific oceans.[3] Additionally, sea snakes are widespread throughout the Indian and Pacific Oceans. More than 20 families are currently recognized, comprising about 500 genera and about 3,400 species.[4][5] They range in size from the tiny, 10.4 cm-long thread snake[6] to the reticulated python of 6.95 meters (22.8 ft) in length.[7] The fossil species *Titanoboa cerrejonensis* was 12.8 meters (42 ft) long.[8] Snakes are thought to have evolved from either burrowing or aquatic lizards, perhaps during the Jurassic period, with the earliest known fossils dating to between 143 and 167 Ma ago.[9] The diversity of modern snakes appeared during the Paleocene period (*c* 66 to 56 Ma ago). The oldest preserved descriptions of snakes can be found in the Brooklyn Papyrus.

Most species are nonvenomous and those that have venom use it primarily to kill and subdue prey rather than for self-defense. Some possess venom potent enough to cause painful injury or death to humans. Nonvenomous snakes either swallow prey alive or kill by constriction.

Snakes

Temporal range:

Late Cretaceous – Present,[1] 94–0 Ma

PreЄ Є O S D C P T J K Pg N

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Reptilia
Order:	Squamata
Clade:	Ophidia
Suborder:	**Serpentes** Linnaeus, 1758

Infraorders

- Alethinophidia Nopcsa, 1923
- Scolecophidia Cope, 1864

Contents

Approximate world distribution of snakes, all species

Etymology

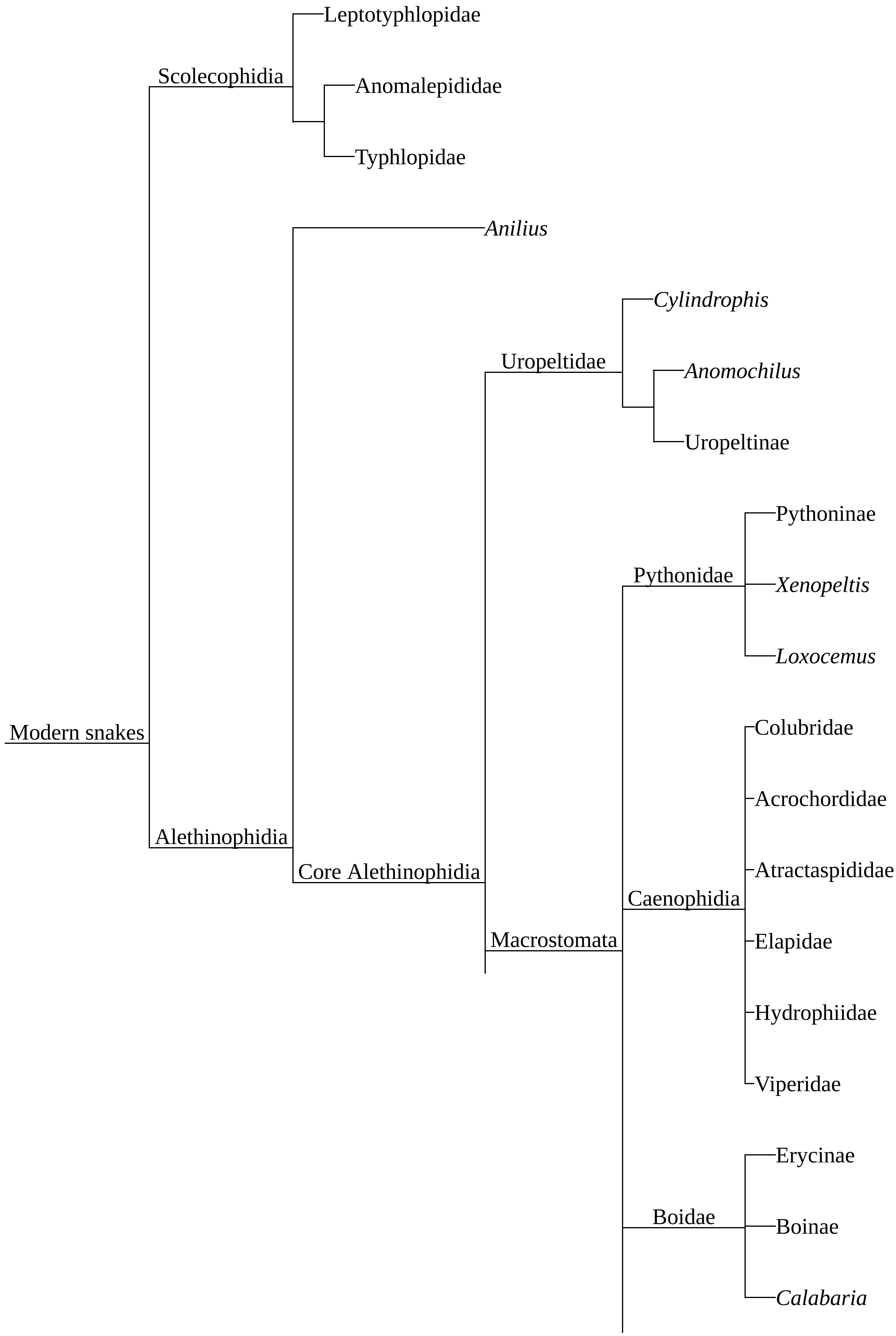
The English word *snake* comes from Old English *snaca*, itself from Proto-Germanic **snak-an-* (cf. Germanic *Schnake* "ring snake", Swedish *snok* "grass snake"), from Proto-Indo-European root **(s)nēg-o-* "to crawl", "to creep", which also gave *sneak* as well as Sanskrit *nāgá* "snake".[10] The word ousted *adder*, as *adder* went on to narrow in meaning, though in Old English *næddre* was the general word for snake.[11] The other term, *serpent*, is from French, ultimately from Indo-European **serp-* (to creep),[12] which also gave Ancient Greek *hérpō* (ἕρπω) "I crawl".

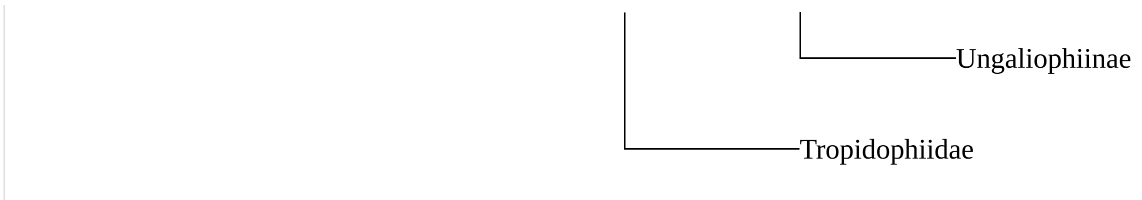
Evolution

The fossil record of snakes is relatively poor because snake skeletons are typically small and fragile making fossilization uncommon. Fossils readily identifiable as snakes (though often retaining hind limbs) first appear in the fossil record during the Cretaceous period.[14] The earliest known true snake fossils (members of the crown group Serpentes) come from the marine simoliophiids, the oldest of which is the Late Cretaceous (Cenomanian age) *Haasiophis terrasanctus*,[1] dated to between 112 and 94 million years old.[15]

Based on comparative anatomy, there is consensus that snakes descended from lizards.[16]:11[17] Pythons and

A phylogenetic overview of the extant groups





Note: the tree only indicates relationships, not evolutionary branching times.[13]

boas—primitive groups among modern snakes—have vestigial hind limbs: tiny, clawed digits known as anal spurs, which are used to grasp during mating.[16]:11[18] The families Leptotyphlopidae and Typhlopidae also possess remnants of the pelvic girdle, appearing as horny projections when visible.

Front limbs are nonexistent in all known snakes. This is caused by the evolution of Hox genes, controlling limb morphogenesis. The axial skeleton of the snakes' common ancestor, like most other tetrapods, had regional specializations consisting of cervical (neck), thoracic (chest), lumbar (lower back), sacral (pelvic), and caudal (tail) vertebrae. Early in snake evolution, the Hox gene expression in the axial skeleton responsible for the development of the thorax became dominant. As a result, the vertebrae anterior to the hindlimb buds (when present) all have the same thoracic-like identity (except from the atlas, axis, and 1–3 neck vertebrae). In other words, most of a snake's skeleton is an extremely extended thorax. Ribs are found exclusively on the thoracic vertebrae. Neck, lumbar and pelvic vertebrae are very reduced in number (only 2–10 lumbar and pelvic vertebrae are present), while only a short tail remains of the caudal vertebrae. However, the tail is still long enough to be of important use in many species, and is modified in some aquatic and tree-dwelling species.

Many modern snake groups originated during the Paleocene, alongside the adaptive radiation of mammals following the extinction of (non-avian) dinosaurs. The expansion of grasslands in North America also led to an explosive radiation among snakes.[19] Previously, snakes were a minor component of the North American fauna, but during the Miocene, the number of species and their prevalence increased dramatically with the first appearances of vipers and elapids in North America and the significant diversification of Colubridae (including the origin of many modern genera such as Nerodia, Lampopeltis, Pituophis and Pantherophis).[20]

Origins

There is fossil evidence to suggest that snakes may have evolved from burrowing lizards, such as the varanids (or a similar group) during the Cretaceous Period.[21] An early fossil snake relative, *Najash rionegrina,* was a two-legged burrowing animal with a sacrum, and was fully terrestrial.[22] One extant analog of these putative ancestors is the earless monitor *Lanthanotus* of Borneo (though it also is semiaquatic).[23] Subterranean species evolved bodies streamlined for burrowing, and eventually lost their limbs.[23] According to this hypothesis, features such as the transparent, fused eyelids (brille) and loss of external ears evolved to cope with fossorial difficulties, such as scratched corneas and dirt in the ears.[21][23] Some primitive snakes are known to have possessed hindlimbs, but their pelvic bones lacked a direct connection to the vertebrae. These include fossil species like *Haasiophis*, *Pachyrhachis* and *Eupodophis,* which are slightly older than *Najash*.[18]

This hypothesis was strengthened in 2015 by the discovery of a 113m year-old fossil of a four-legged snake in Brazil that has been named *Tetrapodophis amplectus*. It has many snake-like features, is adapted for burrowing and its stomach indicates that it was preying on other animals.[24] It is currently uncertain if *Tetrapodophis* is a snake or another species, in the squamate order, as a snake-like body has independently evolved at least 26 times. *Tetrapodophis* does not have distinctive snake features in its spine and skull.[25][26]

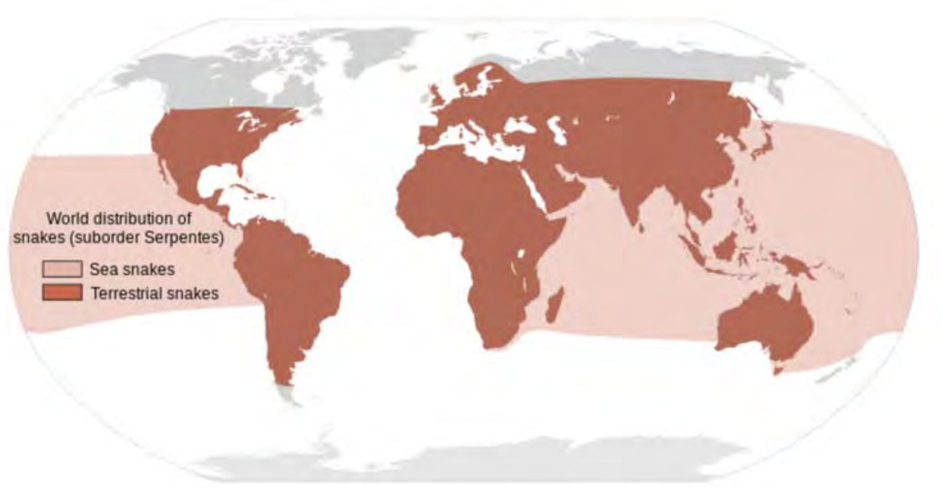
An alternative hypothesis, based on morphology, suggests the ancestors of snakes were related to mosasaurs —extinct aquatic reptiles from the Cretaceous—which in turn are thought to have derived from varanid lizards.[17] According to this hypothesis, the fused, transparent eyelids of snakes are thought to have evolved to combat marine conditions (corneal water loss through osmosis), and the external ears were lost through disuse in an aquatic environment. This ultimately led to an animal similar to today's sea snakes. In the Late Cretaceous, snakes recolonized land, and continued to diversify into today's snakes. Fossilized snake remains are known from early Late Cretaceous marine sediments, which is consistent with this hypothesis; particularly so, as they are older than the terrestrial *Najash rionegrina*. Similar skull structure, reduced or absent limbs, and other anatomical features found in both mosasaurs and snakes lead to a positive cladistical correlation, although some of these features are shared with varanids.

Fossil of *Archaeophis proavus*.

Genetic studies in recent years have indicated snakes are not as closely related to monitor lizards as was once believed—and therefore not to mosasaurs, the proposed ancestor in the aquatic scenario of their evolution. However, more evidence links mosasaurs to snakes than to varanids. Fragmented remains found from the Jurassic and Early Cretaceous indicate deeper fossil records for these groups, which may potentially refute either hypothesis.

In 2016 two studies reported that limb loss in snakes is associated with DNA mutations in the Zone of Polarizing Activity Regulatory Sequence (ZRS), a regulatory region of the Sonic hedgehog gene which is critically required for limb development. Most of the adult snakes do not have limbs, but basal snakes such as pythons and boas do have hindlimb rudiments. Python embryos even have fully developed hind limb buds, but their later development is stopped by the DNA mutations in the ZRS. [27][28][29][30]

Distribution



There are over 2,900 species of snakes ranging as far northward as the Arctic Circle in Scandinavia and southward through Australia.[17] Snakes can be found on every continent except Antarctica, in the sea, and as high as 16,000 feet (4,900 m) in the Himalayan Mountains of Asia.[17][31]:143 There are numerous islands from which snakes are absent, such as Ireland, Iceland, and New Zealand[3][31] (although New Zealand's waters are infrequently visited by the yellow-bellied sea snake and the banded sea krait).[32]

Taxonomy

All modern snakes are grouped within the suborder **Serpentes** in Linnean taxonomy, part of the order Squamata, though their precise placement within squamates remains controversial.[4]

The two infraorders of Serpentes are: Alethinophidia and Scolecophidia.[4] This separation is based on morphological characteristics and mitochondrial DNA sequence similarity. Alethinophidia is sometimes split into Henophidia and Caenophidia, with the latter consisting of "colubroid" snakes (colubrids, vipers, elapids, hydrophiids, and atractaspids) and acrochordids, while the other alethinophidian families comprise Henophidia.[33] While not extant today, the Madtsoiidae, a family of giant, primitive, python-like snakes, was around until 50,000 years ago in Australia, represented by genera such as *Wonambi*.

There are numerous debates in the systematics within the group. For instance, many sources classify Boidae and Pythonidae as one family, while some keep the Elapidae and Hydrophiidae (sea snakes) separate for practical reasons despite their extremely close relation.

Recent molecular studies support the monophyly of the clades of modern snakes, scolecophidians, typhlopids + anomalepidids, alethinophidians, core alethinophidians, uropeltids (*Cylindrophis*, *Anomochilus*, uropeltines), macrostomatans, booids, boids, pythonids and caenophidians.[13]

Families

Infraorder **Alethinophidia** 15 families					
Family[4]	**Taxon author**[4]	**Genera**[4]	**Species**[4]	**Common name**	**Geographic range**[34]
Acrochordidae	Bonaparte, 1831	1	3	Wart snakes	Western India and Sri Lanka through tropical Southeast Asia to the Philippines, south through the Indonesian/Malaysian island group to Timor, east through New Guinea to the northern coast of Australia to Mussau Island, the Bismarck Archipelago and Guadalcanal Island in the Solomon Islands.
Aniliidae	Stejneger, 1907	1	1	False coral snake	Tropical South America.
Anomochilidae	Cundall, Wallach, 1993	1	2	Dwarf pipe snakes	West Malaysia and on the Indonesian island of Sumatra.
Atractaspididae	Günther, 1858	12	64	Burrowing asps	Africa and the Middle East.[16][35][36]
Boidae	Gray, 1825	8	43	Boas	Northern, Central and South America, the Caribbean, southeastern Europe and Asia Minor, Northern, Central and East Africa, Madagascar and Reunion Island, the Arabian Peninsula, Central and southwestern Asia, India and Sri Lanka, the Moluccas and New Guinea through to Melanesia and Samoa.

Bolyeriidae	Hoffstetter, 1946	2	2	Splitjaw snakes	Mauritius.
Colubridae	Oppel, 1811	304[5]	1938[5]	Typical snakes	Widespread on all continents, except Antarctica.[37]
Cylindrophiidae	Fitzinger, 1843	1	8	Asian pipe snakes	Sri Lanka east through Myanmar, Thailand, Cambodia, Vietnam and the Malay Archipelago to as far east as Aru Islands off the southwestern coast of New Guinea. Also found in southern China (Fujian, Hong Kong and on Hainan Island) and in Laos.
Elapidae	Boie, 1827	61	235	Elapids	On land, worldwide in tropical and subtropical regions, except in Europe. Sea snakes occur in the Indian Ocean and the Pacific.[38]
Loxocemidae	Cope, 1861	1	1	Mexican burrowing snake	Along the Pacific versant from Mexico south to Costa Rica.
Pythonidae	Fitzinger, 1826	8	26	Pythons	Subsaharan Africa, India, Myanmar, southern China, Southeast Asia and from the Philippines southeast through Indonesia to New Guinea and Australia.
Tropidophiidae	Brongersma, 1951	4	22	Dwarf boas	From southern Mexico and Central America, south to northwestern South America in Colombia, (Amazonian) Ecuador and Peru, as well as in northwestern and southeastern Brazil. Also found in the West Indies.
Uropeltidae	Müller, 1832	8	47	Shield-tailed snakes	Southern India and Sri Lanka.
Viperidae	Oppel, 1811	32	224	Vipers	The Americas, Africa and Eurasia.
Xenopeltidae	Bonaparte, 1845	1	2	Sunbeam snakes	Southeast Asia from the Andaman and Nicobar Islands, east through Myanmar to southern China, Thailand, Laos, Cambodia, Vietnam, the Malay Peninsula and the East Indies to Sulawesi, as well as the Philippines.

Infraorder **Scolecophidia** 3 families					
Family[4]	**Taxon author**[4]	**Genera**[4]	**Species**[4]	**Common name**	**Geographic range**[34]

Anomalepidae	Taylor, 1939	4	15	Primitive blind snakes	From southern Central America to northwestern South America. Disjunct populations in northeastern and southeastern South America.
Leptotyphlopidae	Stejneger, 1892	2	87	Slender blind snakes	Africa, western Asia from Turkey to northwestern India, on Socotra Island, from the southwestern United States south through Mexico and Central to South America, though not in the high Andes. In Pacific South America they occur as far south as southern coastal Peru, and on the Atlantic side as far as Uruguay and Argentina. In the Caribbean they are found on the Bahamas, Hispaniola and the Lesser Antilles.
Typhlopidae	Merrem, 1820	6	203	Typical blind snakes	Most tropical and many subtropical regions around the world, particularly in Africa, Madagascar, Asia, islands in the Pacific, tropical America and in southeastern Europe.

Legless lizards

While snakes are limbless reptiles, which evolved from (and are grouped with) lizards, there are many other species of lizards which have lost their limbs independently and superficially look similar to snakes. These include the slow worm and glass snake.

Biology

Size

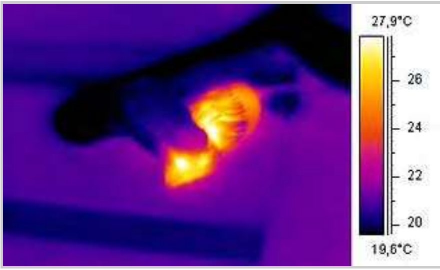
The now extinct *Titanoboa cerrejonensis* snakes found were 12.8 m (42 ft) in length.[8] By comparison, the largest extant snakes are the reticulated python, which measures about 6.95 m (22.8 ft) long,[7] and the anaconda, which measures about 5.21 m (17.1 ft) long and is considered the heaviest snake on Earth at 97.5 kg (215 lb).[39]

An adult Barbados threadsnake, *Leptotyphlops carlae*, on an American quarter dollar.

At the other end of the scale, the smallest extant snake is *Leptotyphlops carlae*, with a length of about 10.4 cm (4.1 in).[6] Most snakes are fairly small animals, approximately 1 m (3.3 ft) in length.[40]

Perception

Pit vipers, pythons, and some boas have infrared-sensitive receptors in deep grooves on the snout, which allow them to "see" the radiated heat of warm-blooded prey. In pit vipers, the grooves are located between the nostril and the eye in a large "pit" on each side of the head. Other infrared-sensitive snakes have multiple, smaller

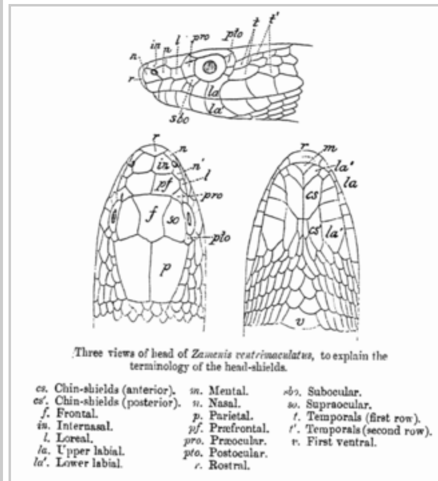


Thermographic image of a snake eating a mouse.

labial pits lining the upper lip, just below the nostrils.[41]

Snakes use smell to track their prey. They smell by using their forked tongues to collect airborne particles, then passing them to the vomeronasal organ or *Jacobson's organ* in the mouth for examination.[41] The fork in the tongue gives snakes a sort of directional sense of smell and taste simultaneously.[41] They keep their tongues constantly in motion, sampling particles from the air, ground, and water, analyzing the chemicals found, and determining the presence of prey or predators in the local environment. In water-dwelling snakes, such as the anaconda, the tongue functions efficiently underwater.[41]

The underside is very sensitive to vibration. This allows snakes to be able to sense approaching animals by detecting faint vibrations in the ground.[41]



A line diagram from G.A. Boulenger's Fauna of British India (1890) illustrating the terminology of shields on the head of a snake.

Snake vision varies greatly, from only being able to distinguish light from dark to keen eyesight, but the main trend is that their vision is adequate although not sharp, and allows them to track movements.[42] Generally, vision is best in arboreal snakes and weakest in burrowing snakes. Some snakes, such as the Asian vine snake (genus *Ahaetulla*), have binocular vision, with both eyes capable of focusing on the same point. Most snakes focus by moving the lens back and forth in relation to the retina, while in the other amniote groups, the lens is stretched. Many nocturnal snakes have slit pupils while diurnal snakes have round pupils.

Skin

The skin of a snake is covered in scales. Contrary to the popular notion of snakes being slimy because of possible confusion of snakes with worms, snakeskin has a smooth, dry texture. Most snakes use specialized belly scales to travel, gripping surfaces. The body scales may be smooth, keeled, or granular. The eyelids of a snake are transparent "spectacle" scales, which remain permanently closed, also known as brille.

The shedding of scales is called *ecdysis* (or in normal usage, *molting* or *sloughing*). In the case of snakes, the complete outer layer of skin is shed in one layer.[43] Snake scales are not discrete, but extensions of the epidermis—hence they are not shed separately but as a complete outer layer during each molt, akin to a sock being turned inside out.[44]

The shape and number of scales on the head, back, and belly are often characteristic and used for taxonomic purposes. Scales are named mainly according to their positions on the body. In "advanced" (Caenophidian) snakes, the broad belly scales and rows of dorsal scales correspond to the vertebrae, allowing scientists to count the vertebrae without dissection.

Snakes' eyes are covered by their clear scales (the brille) rather than movable eyelids. Their eyes are always open, and for sleeping, the retina can be closed or the face buried among the folds of the body.

Molting

A snake shedding its skin.

Molting serves a number of functions. Firstly, the old and worn skin is replaced; secondly, it helps get rid of parasites such as mites and ticks. Renewal of the skin by moulting is supposed to allow growth in some animals such as insects; however, this has been disputed in the case of snakes.[44][45]

Molting occurs periodically throughout the snake's life. Before a molt, the snake stops eating and often hides or moves to a safe place. Just before shedding, the skin becomes dull and dry looking and the eyes become cloudy or blue-colored. The inner surface of the old skin liquefies. This causes the old skin to separate from the new skin beneath it. After a few days, the eyes clear and the snake "crawls" out of its old skin. The old skin breaks near the mouth and the snake wriggles out, aided by rubbing against rough surfaces. In many cases, the cast skin peels backward over the body from head to tail in one piece, like pulling a sock off inside-out. A new, larger, brighter layer of skin has formed underneath.[44][46]

An older snake may shed its skin only once or twice a year. But a younger snake, still growing, may shed up to four times a year.[46] The discarded skin gives a perfect imprint of the scale pattern, and it is usually possible to identify the snake if the discarded skin is reasonably intact.[44] This periodic renewal has led to the snake being a symbol of healing and medicine, as pictured in the Rod of Asclepius.[47]

Scale counts can sometimes be used to tell the sex of a snake when the species is not distinctly sexually dimorphic. A probe is inserted into the cloaca until it can go no further. The probe is marked at the point where it stops, removed, and compared to the subcaudal depth by laying it alongside the scales.[48] The scalation count determines whether the snake is a male or female as hemipenes of a male will probe to a different depth (usually longer) than the cloaca of a female.[48]

Skeleton

When compared, the skeletons of snakes are radically different from those of most other reptiles (such as the turtle, right), being made up almost entirely of an extended ribcage.

The skeleton of most snakes consists solely of the skull, hyoid, vertebral column, and ribs, though henophidian snakes retain vestiges of the pelvis and rear limbs.

The skull of the snake consists of a solid and complete neurocranium, to which many of the other bones are only loosely attached, particularly the highly mobile jaw bones, which facilitate manipulation and ingestion of large prey items. The left and right sides of the lower jaw are joined only by a flexible ligament at the anterior tips, allowing them to separate widely, while the posterior end of the lower jaw bones articulate with a quadrate bone, allowing further mobility. The bones of the mandible and quadrate bones can also pick up ground borne vibrations.[49] Because the sides of the jaw can move independently of one another, snakes resting their jaws on a surface have sensitive stereo hearing which can detect the position of prey. The jaw-quadrate-stapes pathway is capable of detecting vibrations on the angstrom scale, despite the absence of an outer ear and the ossicle mechanism of impedance matching used in other vertebrates to receive vibrations from the air.[50][51]

The hyoid is a small bone located posterior and ventral to the skull, in the 'neck' region, which serves as an attachment for muscles of the snake's tongue, as it does in all other tetrapods.

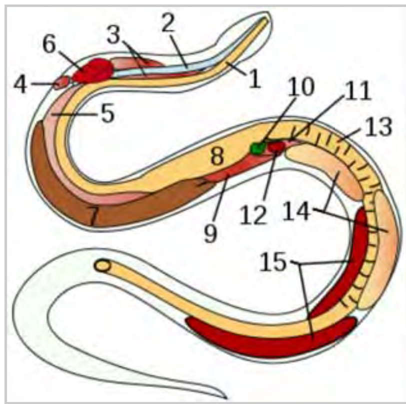
The vertebral column consists of anywhere between 200 and 400 (or more) vertebrae. Tail vertebrae are comparatively few in number (often less than 20% of the total) and lack ribs, while body vertebrae each have two ribs articulating with them. The vertebrae have projections that allow for strong muscle attachment enabling locomotion without limbs.

Autotomy of the tail, a feature found in some lizards is absent in most snakes.[52] Caudal autotomy in snakes is rare and is intervertebral, unlike that in lizards, which is intravertebral—that is, the break happens along a predefined fracture plane present on a vertebra.[53][54]

In some snakes, most notably boas and pythons, there are vestiges of the hindlimbs in the form of a pair of pelvic spurs. These small, claw-like protrusions on each side of the cloaca are the external portion of the vestigial hindlimb skeleton, which includes the remains of an ilium and femur.

Snakes are polyphyodonts with teeth that are continuously replaced.[55]

Internal organs



Anatomy of a snake.file info

1. esophagus
2. trachea
3. tracheal lungs
4. rudimentary left lung
5. right lung
6. heart
7. liver
8. stomach
9. air sac
10. gallbladder
11. pancreas
12. spleen
13. intestine
14. testicles
15. kidneys

The snake's heart is encased in a sac, called the *pericardium*, located at the bifurcation of the bronchi. The heart is able to move around, however, owing to the lack of a diaphragm. This adjustment protects the heart from potential damage when large ingested prey is passed through the esophagus. The spleen is attached to the gall bladder and pancreas and filters the blood. The thymus gland is located in fatty tissue above the heart and is responsible for the generation of immune cells in the blood. The cardiovascular system of snakes is also unique for the presence of a renal portal system in which the blood from the snake's tail passes through the kidneys before returning to the heart.[56]

The vestigial left lung is often small or sometimes even absent, as snakes' tubular bodies require all of their organs to be long and thin.[56] In the majority of species, only one lung is functional. This lung contains a vascularized anterior portion and a posterior portion that does not function in gas exchange.[56] This 'saccular lung' is used for hydrostatic purposes to adjust buoyancy in some aquatic snakes and its function remains unknown in terrestrial species.[56] Many organs that are paired, such as kidneys or reproductive organs, are staggered within the body, with one located ahead of the other.[56]

Snakes have no lymph nodes.[56]

Venom

Cobras, vipers, and closely related species use venom to immobilize or kill their prey. The venom is modified saliva, delivered through fangs.[16]:243 The fangs of 'advanced' venomous snakes like viperids and elapids are hollow to inject venom more effectively, while the fangs of rear-fanged snakes such as the boomslang merely have a groove on the posterior edge to channel venom into the wound. Snake venoms are often prey specific—their role in self-defense is secondary.[16]:243

Milk snakes are often mistaken for coral snakes whose venom is deadly to humans.

Venom, like all salivary secretions, is a predigestant that initiates the breakdown of food into soluble compounds, facilitating proper digestion. Even nonvenomous snake bites (like any animal bite) will cause tissue damage.[16]:209

Certain birds, mammals, and other snakes (such as kingsnakes) that prey on venomous snakes have developed resistance and even immunity to certain venoms.[16]:243 Venomous snakes include three families of snakes, and do not constitute a formal classification group used in taxonomy.

The colloquial term "poisonous snake" is generally an incorrect label for snakes. A poison is inhaled or ingested, whereas venom produced by snakes is injected into its victim via fangs.[57] There are, however, two exceptions: *Rhabdophis* sequesters toxins from the toads it eats, then secretes them from nuchal glands to ward off predators, and a small unusual population of garter snakes in the U.S. state of Oregon retains enough toxins in their livers from the newts they eat to be effectively poisonous to small local predators (such as crows and foxes).[58]

Snake venoms are complex mixtures of proteins, and are stored in venom glands at the back of the head.[58] In all venomous snakes, these glands open through ducts into grooved or hollow teeth in the upper jaw.[16]:243[57] These proteins can potentially be a mix of neurotoxins (which attack the nervous system), hemotoxins (which attack the circulatory system), cytotoxins, bungarotoxins and many other toxins that affect the body in different ways.[57] Almost all snake venom contains *hyaluronidase*, an enzyme that ensures rapid diffusion of the venom.[16]:243

Venomous snakes that use hemotoxins usually have fangs in the front of their mouths, making it easier for them to inject the venom into their victims.[57] Some snakes that use neurotoxins (such as the mangrove snake) have fangs in the back of their mouths, with the fangs curled backwards.[59] This makes it difficult both for the snake to use its venom and for scientists to milk them.[57] *Elapids*, however, such as cobras and kraits are *proteroglyphous*—they possess hollow fangs that cannot be erected toward the front of their mouths, and cannot "stab" like a viper. They must actually bite the victim.[16]:242

It has recently been suggested that all snakes may be venomous to a certain degree, with harmless snakes having weak venom and no fangs.[60] Most snakes currently labelled "nonvenomous" would still be considered harmless according to this theory, as they either lack a venom delivery method or are incapable of delivering enough to endanger a human. This theory postulates that snakes may have evolved from a common lizard ancestor that was venomous—and that venomous lizards like the gila monster, beaded lizard, monitor lizards, and the now-extinct mosasaurs may also have derived from it. They share this venom clade with various other saurian species.

Venomous snakes are classified in two taxonomic families:

- **Elapids** – cobras including king cobras, kraits, mambas, Australian copperheads, sea snakes, and coral snakes.[59]
- **Viperids** – vipers, rattlesnakes, copperheads/cottonmouths, and bushmasters.[59]

There is a third family containing the *opistoglyphous* (rear-fanged) snakes (as well as the majority of other snake species):

- **Colubrids –** boomslangs, tree snakes, vine snakes, mangrove snakes, although not all colubrids are venomous.[16]:209[59]

Reproduction

Although a wide range of reproductive modes are used by snakes, all snakes employ internal fertilization. This is accomplished by means of paired, forked hemipenes, which are stored, inverted, in the male's tail.[61] The hemipenes are often grooved, hooked, or spined in order to grip the walls of the female's cloaca.[61]

Most species of snakes lay eggs which they abandon shortly after laying. However, a few species (such as the king cobra) actually construct nests and stay in the vicinity of the hatchlings after incubation.[61] Most pythons coil around their egg-clutches and remain with them until they hatch.[62] A female python will not leave the eggs, except to occasionally bask in the sun or drink water. She will even "shiver" to generate heat to incubate the eggs.[62]

Some species of snake are ovoviviparous and retain the eggs within their bodies until they are almost ready to hatch.[63][64] Recently, it has been confirmed that several species of snake are fully viviparous, such as the boa constrictor and green anaconda, nourishing their young through a placenta as well as a yolk sac, which is highly unusual among reptiles, or anything else outside of requiem sharks or placental mammals.[63][64] Retention of eggs and live birth are most often associated with colder environments.[61][64]

Sexual selection in snakes is demonstrated by the three thousand species that each use different tactics in acquiring mates.[65] Ritual combat between males for the females they want to mate with includes topping, a behavior exhibited by most viperids in which one male will twist around the vertically elevated fore body of its opponent and forcing it downward. It is common for neck biting to occur while the snakes are entwined.[66]

The Garter snake has been studied for sexual selection

Facultative parthenogenesis

Parthenogenesis is a natural form of reproduction in which growth and development of embryos occur without fertilization. *Agkistrodon contortrix* (copperhead) and *Agkistrodon piscivorus* (cotton mouth) can reproduce by facultative parthenogenesis. That is, they are capable of switching from a sexual mode of reproduction to an asexual mode.[67] The type of parthenogenesis that likely occurs is automixis with terminal fusion, a process in which two terminal products from the same meiosis fuse to form a diploid zygote. This process leads to genome wide homozygosity, expression of deleterious recessive alleles and often to developmental abnormalities. Both captive-born and wild-born *A. contortrix* and *A. piscivorus* appear to be capable of this form of parthenogenesis.[67]

Reproduction in squamate reptiles is almost exclusively sexual. Males ordinarily have a ZZ pair of sex determining chromosomes, and females a ZW pair. However, the Colombian Rainbow boa, *Epicrates maurus* can also reproduce by facultative parthenogenesis resulting in production of WW female progeny.[68] The WW females are likely produced by terminal automixis.

Behavior

Winter dormancy

In regions where winters are colder than snakes can tolerate while remaining active, local species will brumate. Unlike hibernation, in which mammals are actually asleep, brumating reptiles are awake but inactive. Individual snakes may brumate in burrows, under rock piles, or inside fallen trees, or snakes may aggregate in large numbers at hibernacula.

Feeding and diet


African egg-eating snake eating an egg


Carpet python constricting and consuming a chicken.

All snakes are strictly carnivorous, eating small animals including lizards, frogs, other snakes, small mammals, birds, eggs, fish, snails or insects.[16][3][17][69] Because snakes cannot bite or tear their food to pieces, they must swallow prey whole. The body size of a snake has a major influence on its eating habits. Smaller snakes eat smaller prey. Juvenile pythons might start out feeding on lizards or mice and graduate to small deer or antelope as an adult, for example.

The snake's jaw is a complex structure. Contrary to the popular belief that snakes can dislocate their jaws, snakes have a very flexible lower jaw, the two halves of which are not rigidly attached, and numerous other joints in their skull (see snake skull), allowing them to open their mouths wide enough to swallow their prey whole, even if it is larger in diameter than the snake itself.[69] For example, the African egg-eating snake has flexible jaws adapted for eating eggs much larger than the diameter of its head.[16]:81 This snake has no teeth, but does have bony protrusions on the inside edge of its spine, which it uses to break shells when it eats eggs.[16]:81

While the majority of snakes eat a variety of prey animals, there is some specialization by some species. King cobras and the Australian bandy-bandy consume other snakes. *Pareas iwesakii* and other snail-eating colubrids of subfamily Pareatinae have more teeth on the right side of their mouths than on the left, as the shells of their prey usually spiral clockwise[16]:184[70]

Some snakes have a venomous bite, which they use to kill their prey before eating it.[69][71] Other snakes kill their prey by constriction.[69] Still others swallow their prey whole and alive.[16]:81[69]

After eating, snakes become dormant while the process of digestion takes place.[48] Digestion is an intense activity, especially after consumption of large prey. In species that feed only sporadically, the entire intestine enters a reduced state between meals to conserve energy. The digestive system is then 'up-regulated' to full capacity within 48 hours of prey consumption. Being ectothermic ("cold-blooded"), the surrounding temperature plays a large role in snake digestion. The ideal temperature for snakes to digest is 30 °C (86 °F). So much metabolic energy is involved in a snake's digestion that in the Mexican rattlesnake (*Crotalus* *durissus*), surface body temperature increases by as much as 1.2 °C (2.2 °F) during the digestive process.[72] Because of this, a snake disturbed after having eaten recently will often regurgitate its prey to be able to escape the perceived threat. When undisturbed, the digestive process is highly efficient, with the snake's digestive enzymes dissolving and absorbing everything but the prey's hair (or feathers) and claws, which are excreted along with waste.

Dolichophis jugularis preying on a Sheltopusik.

Locomotion

The lack of limbs does not impede the movement of snakes. They have developed several different modes of locomotion to deal with particular environments. Unlike the gaits of limbed animals, which form a continuum, each mode of snake locomotion is discrete and distinct from the others; transitions between modes are abrupt.[73][74]

Lateral undulation

Crawling prints of a snake

Lateral undulation is the sole mode of aquatic locomotion, and the most common mode of terrestrial locomotion.[74] In this mode, the body of the snake alternately flexes to the left and right, resulting in a series of rearward-moving "waves".[73] While this movement appears rapid, snakes have rarely been documented moving faster than two body-lengths per second, often much less.[75] This mode of movement has the same net cost of transport (calories burned per meter moved) as running in lizards of the same mass.[76]

Terrestrial lateral undulation is the most common mode of terrestrial locomotion for most snake species.[73] In this mode, the posteriorly moving waves push against contact points in the environment, such as rocks, twigs, irregularities in the soil, etc.[73] Each of these environmental objects, in turn, generates a reaction force directed forward and towards the midline of the snake, resulting in forward thrust while the lateral components cancel out.[77] The speed of this movement depends upon the density of push-points in the environment, with a medium density of about 8 along the snake's length being ideal.[75] The wave speed is precisely the same as the snake speed, and as a result, every point on the snake's body follows the path of the point ahead of it, allowing snakes to move through very dense vegetation and small openings.[77]

When swimming, the waves become larger as they move down the snake's body, and the wave travels backwards faster than the snake moves forwards.[78] Thrust is generated by pushing their body against the water, resulting in the observed slip. In spite of overall similarities, studies show that the pattern of muscle activation is different in aquatic versus terrestrial lateral undulation, which justifies calling them separate modes.[79] All snakes can laterally undulate forward (with backward-moving waves), but only sea snakes have been observed reversing the motion (moving backwards with forward-moving waves).[73]

Sidewinding

Most often employed by colubroid snakes (colubrids, elapids, and vipers) when the snake must move in an environment that lacks irregularities to push against (rendering lateral undulation impossible), such as a slick mud flat, or a sand dune, sidewinding is a modified form of lateral undulation in which all of the body segments oriented in one direction remain in contact with the ground, while the other segments are lifted up, resulting in a peculiar "rolling" motion.[80][81] This mode of locomotion overcomes the slippery nature of sand or mud by pushing off with only static portions on the body, thereby minimizing slipping.[80] The static nature of the contact points can be shown from the tracks of a sidewinding snake, which show each belly scale imprint, without any smearing. This mode of locomotion has very low caloric cost, less than ⅓ of the cost for a lizard to move the same distance.[76] Contrary to popular belief, there is no evidence that sidewinding is associated with the sand being hot.[80]


A neonate sidewinder rattlesnake (*Crotalus cerastes*) sidewinding.

Concertina

When push-points are absent, but there is not enough space to use sidewinding because of lateral constraints, such as in tunnels, snakes rely on concertina locomotion.[73][81] In this mode, the snake braces the posterior portion of its body against the tunnel wall while the front of the snake extends and straightens.[80] The front portion then flexes and forms an anchor point, and the posterior is straightened and pulled forwards. This mode of locomotion is slow and very demanding, up to seven times the cost of laterally undulating over the same distance.[76] This high cost is due to the repeated stops and starts of portions of the body as well as the necessity of using active muscular effort to brace against the tunnel walls.

Arboreal


Golden tree snake climbing a flower

The movement of snakes in arboreal habitats has only recently been studied.[82] While on tree branches, snakes use several modes of locomotion depending on species and bark texture.[82] In general, snakes will use a modified form of concertina locomotion on smooth branches, but will laterally undulate if contact points are available.[82] Snakes move faster on small branches and when contact points are present, in contrast to limbed animals, which do better on large branches with little 'clutter'.[82]

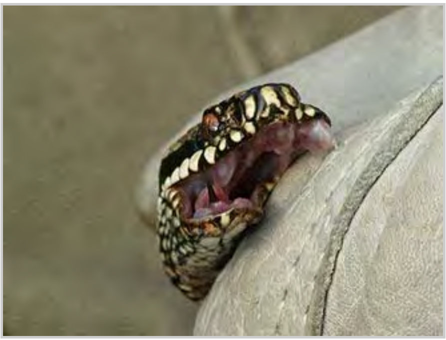
Gliding snakes (*Chrysopelea*) of Southeast Asia launch themselves from branch tips, spreading their ribs and laterally undulating as they glide between trees.[80][83][84] These snakes can perform a controlled glide for hundreds of feet depending upon launch altitude and can even turn in midair.[80][83]

Rectilinear

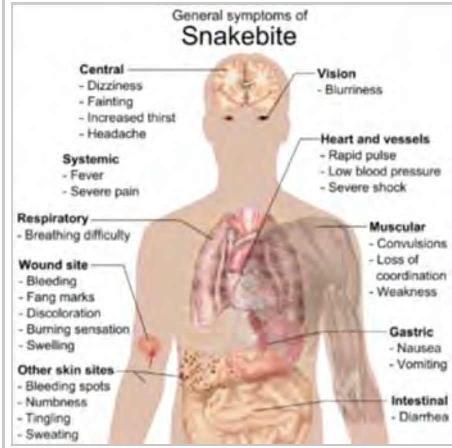
The slowest mode of snake locomotion is rectilinear locomotion, which is also the only one where the snake does not need to bend its body laterally, though it may do so when turning.[85] In this mode, the belly scales are lifted and pulled forward before being placed down and the body pulled over them. Waves of movement and stasis pass posteriorly, resulting in a series of ripples in the skin.[85] The ribs of the snake do not move in this mode of locomotion and this method is most often used by large pythons, boas, and vipers when stalking prey across open ground as the snake's movements are subtle and harder to detect by their prey in this manner.[80]

Interactions with humans

Bite



Vipera berus, one fang in glove with a small venom stain, the other still in place.



Most common symptoms of any kind of snake bite envenomation.[86][87] Furthermore, there is vast variation in symptoms between bites from different types of snakes.[86]

Snakes do not ordinarily prey on humans. Unless startled or injured, most snakes prefer to avoid contact and will not attack humans. With the exception of large constrictors, nonvenomous snakes are not a threat to humans. The bite of a nonvenomous snake is usually harmless; their teeth are not designed for tearing or inflicting a deep puncture wound, but rather grabbing and holding. Although the possibility of infection and tissue damage is present in the bite of a nonvenomous snake, venomous snakes present far greater hazard to humans.[16]:209 The World Health Organisation lists snakebite under the "other neglected conditions" category.[88]

Documented deaths resulting from snake bites are uncommon. Nonfatal bites from venomous snakes may result in the need for amputation of a limb or part thereof. Of the roughly 725 species of venomous snakes worldwide, only 250 are able to kill a human with one bite. Australia averages only one fatal snake bite per year. In India, 250,000 snakebites are recorded in a single year, with as many as 50,000 recorded initial deaths.[89]

The treatment for a snakebite is as variable as the bite itself. The most common and effective method is through antivenom (or antivenin), a serum made from the venom of the snake. Some antivenom is species-specific (monovalent) while some is made for use with multiple species in mind (polyvalent). In the United States for example, all species of venomous snakes are pit vipers, with the exception of the coral snake. To produce antivenom, a mixture of the venoms of the different species of rattlesnakes, copperheads, and cottonmouths is injected into the body of a horse in ever-increasing dosages until the horse is immunized. Blood is then extracted from the immunized horse. The serum is separated and further purified and freeze-dried. It is reconstituted with sterile water and becomes antivenom. For this reason, people who are allergic to horses are more likely to suffer an allergic reaction to antivenom.[90] Antivenom for the more dangerous species (such as mambas, taipans, and cobras) is made in a similar manner in India, South Africa, and Australia, although these antivenoms are species-specific.

Snake charmers

In some parts of the world, especially in India, snake charming is a roadside show performed by a charmer. In such a show, the snake charmer carries a basket that contains a snake that he seemingly charms by playing tunes from his flutelike musical instrument, to which the snake responds.[91] Snakes lack external ears, though they do have internal ears, and respond to the movement of the flute, not the actual noise.[91][92]

An Indian cobra in a basket with a snake charmer. These snakes are perhaps the most common subjects of snake charmings.

The Wildlife Protection Act of 1972 in India technically proscribes snake charming on grounds of reducing animal cruelty. Other snake charmers also have a snake and mongoose show, where both the animals have a mock fight; however, this is not very common, as the snakes, as well as the mongooses, may be seriously injured or killed. Snake charming as a profession is dying out in India because of competition from modern forms of entertainment and environment laws proscribing the practice.[91]

Trapping

The *Irulas* tribe of Andhra Pradesh and Tamil Nadu in India have been hunter-gatherers in the hot, dry plains forests, and have practiced the art of snake catching for generations. They have a vast knowledge of snakes in the field. They generally catch the snakes with the help of a simple stick. Earlier, the *Irulas* caught thousands of snakes for the snake-skin industry. After the complete ban of the snake-skin industry in India and protection of all snakes under the Indian Wildlife (Protection) Act 1972, they formed the Irula Snake Catcher's Cooperative and switched to catching snakes for removal of venom, releasing them in the wild after four extractions. The venom so collected is used for producing life-saving antivenom, biomedical research and for other medicinal products.[93] The *Irulas* are also known to eat some of the snakes they catch and are very useful in rat extermination in the villages.

Despite the existence of snake charmers, there have also been professional snake catchers or wranglers. Modern-day snake trapping involves a herpetologist using a long stick with a V- shaped end. Some television show hosts, like Bill Haast, Austin Stevens, Steve Irwin, and Jeff Corwin, prefer to catch them using bare hands.

Consumption

Snake meat, in a Taipei restaurant

While not commonly thought of as food in most cultures, in some cultures, the consumption of snakes is acceptable, or even considered a delicacy, prized for its alleged pharmaceutical effect of warming the heart. Snake soup of Cantonese cuisine is consumed by local people in autumn, to warm up their body. Western cultures document the consumption of snakes under extreme circumstances of hunger.[94] Cooked rattlesnake meat is an exception, which is commonly consumed in parts of the Midwestern United States. In Asian countries such as China, Taiwan, Thailand, Indonesia, Vietnam and Cambodia, drinking the blood of snakes—particularly the cobra—is believed to increase sexual virility.[95] The blood is drained while the cobra is still alive

A "海豹蛇" ("sea-leopard snake", supposedly *Enhydris bocourti*) occupies a place of honor among the live delicacies waiting to meet their consumers outside of a Guangzhou restaurant.

when possible, and is usually mixed with some form of liquor to improve the taste.[95]

In some Asian countries, the use of snakes in alcohol is also accepted. In such cases, the body of a snake or several snakes is left to steep in a jar or container of liquor. It is claimed that this makes the liquor stronger (as well as more expensive). One example of this is the Habu snake sometimes placed in the Okinawan liquor Awamori also known as "Habu Sake".[96]

Snake wine (蛇酒) is an alcoholic beverage produced by infusing whole snakes in rice wine or grain alcohol. The drink was first recorded to have been consumed in China during the Western Zhou dynasty and considered an important curative and believed to reinvigorate a person according to Traditional Chinese medicine.[97]

Pets

In the Western world, some snakes (especially docile species such as the ball python and corn snake) are kept as pets. To meet this demand a captive breeding industry has developed. Snakes bred in captivity tend to make better pets and are considered preferable to wild caught specimens.[98] Snakes can be very low maintenance pets, especially compared to more traditional species. They require minimal space, as most common species do not exceed five feet (1.5 m) in length. Pet snakes can be fed relatively infrequently, usually once every 5 to 14 days. Certain snakes have a lifespan of more than 40 years if given proper care.

Symbolism

In Egyptian history, the snake occupies a primary role with the Nile cobra adorning the crown of the pharaoh in ancient times. It was worshipped as one of the gods and was also used for sinister purposes: murder of an adversary and ritual suicide (Cleopatra).

The reverse side of the throne of Pharaoh Tutankhamun with four golden uraeus cobra figures. Gold with lapis lazuli; Valley of the Kings, Thebes(1347-37 BCE).

Medusa by 16th-century Italian artist Caravaggio.

In Greek mythology snakes are often associated with deadly and dangerous antagonists, but this is not to say that snakes are symbolic of evil; in fact, snakes are a chthonic symbol, roughly translated as 'earthbound'. The nine-headed Lernaean Hydra that Hercules defeated and the three Gorgon sisters are children of Gaia, the earth.[99] Medusa was one of the three Gorgon sisters who Perseus defeated.[99] Medusa is described as a hideous mortal, with snakes instead of hair and the power to turn men to stone with her gaze.[99] After killing her, Perseus gave her head to Athena who fixed it to her shield called the Aegis.[99] The Titans are also depicted in art with snakes instead of legs and feet for the same reason—they are children of Gaia and Uranus, so they are bound to the earth.

The legendary account of the foundation of Thebes mentioned a monster snake guarding the spring from which the new settlement was to draw its water. In fighting and killing the snake, the companions of the founder Cadmus all perished - leading to the term "Cadmean victory" (i.e. a victory involving one's own ruin).

Three medical symbols involving snakes that are still used today are Bowl of Hygieia, symbolizing pharmacy,

Imperial Japan depicted as an evil snake in a WWII propaganda poster.

and the Caduceus and Rod of Asclepius, which are symbols denoting medicine in general.[47]


Rod of Asclepius, in which the snake, through ecdysis, symbolizes healing.

India is often called the land of snakes and is steeped in tradition regarding snakes.[100] Snakes are worshipped as gods even today with many women pouring milk on snake pits (despite snakes' aversion for milk).[100] The cobra is seen on the neck of Shiva and Vishnu is depicted often as sleeping on a seven-headed snake or within the coils of a serpent.[101] There are also several temples in India solely for cobras sometimes called *Nagraj* (King of Snakes) and it is believed that snakes are symbols of fertility. There is a Hindu festival called Nag Panchami each year on which day snakes are venerated and prayed to. See also *Nāga*.

In India there is another mythology about snakes. Commonly known in Hindi as "Ichchhadhari" snakes. Such snakes can take the form of any living creature, but prefer human form. These mythical snakes possess a valuable gem called "Mani", which is more brilliant than diamond. There are many stories in India about greedy people trying to possess this gem and ending up getting killed.

The ouroboros is a symbol associated with many different religions and customs, and is claimed to be related to alchemy. The ouroboros or uroboros is a snake eating its own tail in a clock-wise direction (from the head to the tail) in the shape of a circle, representing the cycle of life, death and rebirth, leading to immortality.

The snake is one of the 12 celestial animals of Chinese Zodiac, in the Chinese calendar.

Many ancient Peruvian cultures worshipped nature.[102] They emphasized animals and often depicted snakes in their art.[103]

Religion


A snake associated with Saint Simeon Stylites.

Snakes are a part of Hindu worship. A festival, Nag Panchami, in which participants worship either images of or live Nāgas (cobras) is celebrated every year. Most images of Lord Shiva depict snake around his neck. Puranas have various stories associated with snakes. In the Puranas, Shesha is said to hold all the planets of the Universe on his hoods and to constantly sing the glories of Vishnu from all his mouths. He is sometimes referred to as "Ananta-Shesha", which means "Endless Shesha". Other notable snakes in Hinduism are Ananta, Vasuki, Taxak, Karkotaka and Pingala. The term Nāga is used to refer to entities that take the form of large snakes in Hinduism and Buddhism.

Snakes have also been widely revered, such as in ancient Greece, where the serpent was seen as a healer. Asclepius carried a serpent wound around his wand, a symbol seen today on many ambulances.

In religious terms, the snake and jaguar are arguably the most important animals in ancient Mesoamerica. "In states of ecstasy, lords dance a serpent dance; great descending snakes adorn and support buildings from Chichen Itza to Tenochtitlan, and the Nahuatl word *coatl* meaning serpent or twin, forms part of primary deities such as Mixcoatl, Quetzalcoatl, and Coatlicue."[104] In both Maya and Aztec calendars, the fifth day of the week was known as Snake Day.

In Judaism, the snake of brass is also a symbol of healing, of one's life being saved from imminent death.[105]

In some parts of Christianity, Christ's redemptive work is compared to saving one's life through beholding the Nehushtan (serpent of brass).[106] Snake handlers use snakes as an integral part of church worship in order to exhibit their faith in divine protection. However, more commonly in Christianity, the serpent has been seen as a representative of evil and sly plotting, which can be seen in the description in Genesis chapter 3 of a snake in the Garden of Eden tempting Eve.[107] Saint Patrick is reputed to have expelled all snakes from Ireland while converting the country to Christianity in the 5th century, thus explaining the absence of snakes there.

In Christianity and Judaism, the snake makes its infamous appearance in the first book of the Bible when a serpent appears before the first couple Adam and Eve and tempts them with the forbidden fruit from the Tree of Knowledge.[107] The snake returns in Exodus when Moses, as a sign of God's power, turns his staff into a snake and when Moses made the Nehushtan, a bronze snake on a pole that when looked at cured the people of bites from the snakes that plagued them in the desert. The serpent makes its final appearance symbolizing Satan in the Book of Revelation: "And he laid hold on the dragon the old serpent, which is the devil and Satan, and bound him for a thousand years."[108]

In Neo-Paganism and Wicca, the snake is seen as a symbol of wisdom and knowledge.

Medicine

Ballcourt marker from the Postclassic site of Mixco Viejo in Guatemala. This sculpture depicts Kukulkan, jaws agape, with the head of a human warrior emerging from his maw.[109]

The cytotoxic effect of snake venom is being researched as a potential treatment for cancers.[110]

See also

- Legend of the White Snake
- The Green Snake and the Beautiful Lily (Goethe's archetypal tale of consciousness)
- Limbless vertebrates
- List of Serpentes families
- List of snakes
- Ophiology
- Snake skeleton
- Spinal osteoarthropathy (reptile disease)
- *The New Encyclopedia of Snakes*
- The Snakes of Europe and Snakes of Europe Wikibooks:Snakes of Europe, a wikibook
- Venomous snake

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