What's Inside Your Snake!? A Look Inside Snake Anatomy!

I. Introduction

There is little doubt that snakes are some of the most feared and revered groups of animals, at least among vertebrate animals (animals with a spinal cord or vertebra). As discussed in previous articles this is often because of their vastly different appearance due to evolution over thousands, if not millions of years, than the mammals we are much more familiar with. Their elongated, limbless or legless bodies, lack of eyelids and ability to blink, lack of external ears, and hardened scales covering their bodies instead of hair or feathers all make snakes, as well as other reptiles and amphibians, a very unique groups of animals.

We've certainly covered all of the five senses: sight, hearing, smell, taste, and touch, which snakes, other reptiles, amphibians, and many other organisms have in some shape or form in our previous article, "How Much "Sense" Do You Have About Snakes", as well as how similar as how they compare to our own senses. But what if we dug a little deeper into our beloved snakes, beneath their skin and scales, to examine their actual internal anatomy and structure? What organs and organ systems do they have, or not? How are they similar and different from our own, or mammals in general? What purposes and functions do they serve?

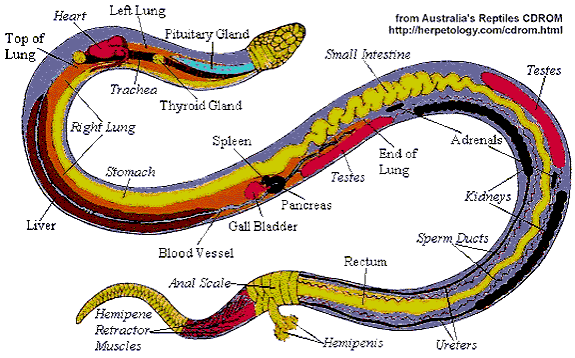


**Figure-Overall Internal Organs and Organ Systems of a Snake. Photo Credit: Australian Reptiles CDROM.*

More could be written in greater depth and detail when it comes to snake anatomy and physiology. New discoveries and findings have been, and certainly will continue to be made into the purposes and functions of the organs and organ systems of these amazing animals. There are also some aspects of their anatomy and physiology that are still not well known or understood by the general public or community as well. Believe it or not, many may not even realize that snakes have bones and other internal organs. It is the hope of this educational article, that by providing an examination and introduction to each of the eleven (11) basic organ systems

(integumentary system, respiratory system, skeletal system, muscular system, nervous system, endocrine system, cardiovascular system, lymphatic system, digestive system, excretory system, and reproductive system) that more can be seen about their insides to provide more insight into how these animals are actually more similar to us, and all other vertebrate animals, than we may have previously

believed!

**Figure-Snake Skeleton. Photo Credit: DK Find Out!*

II. Skeletal System:

Contrary to a popular belief, all snakes do have an internal skeletal structure and bones. Their internal skeletons are obviously less complex than those of other vertebrate animals, owing to their lack of joints, appendages, or limbs such as arms or legs. However, some more primitive groups of snakes such as the Boidae (boas) and Pythonidae (pythons) still possess vestigial, or remnant pelvic girdles or similar structures known as **"spurs"**. The spurs are used primarily during mating and reproduction.

Snakes also possess **vertebrae**, which can number anywhere from 130 to 500 (or more), depending on the species or scientific group of snakes, one or more pairs of **ribs** are attched to each vertebrae. The bones in their cloacal, or tails are comprised of additional vertebrae segments as well.

All snakes also have **skulls**, which contain the most diverse groupings of bones in a snake's skeletal structure. **Qadrate bones**, or lower jaw bones, and **maxilla bones**, or their upper jaw bones, are very flexible, and are connected by loose muscles, tendons, and ligaments, which allow most snakes to swallow prey items larger than their heads! Contrary to popular belief, snakes do not actually "dislocate" their jaws when ingesting a meal. The joints of both their upper and lower jaws are located quite far back, and their lower jaw bones are also not fused anteriorly, or in their fronts, allowing them to move laterally when swallowing larger prey.

The vast majority of snakes do have **teeth**, which can vary in their overall number, number of rows, shape, and orientation depending on the species or group of snakes. Most are recurved in order to grip their prey and aid in swallowing and ingesting. Different species of snakes can have different types of teeth depending on their diets and their different methods used to capture and ingest prey. Snake teeth are both **acrodonts**, or attached to their jaw bones, and **polyphydonts**, meaning they are able to constantly shed and replace their teeth and/or fangs throughout their lives whenever they are lost or damaged, or when the snake grows.

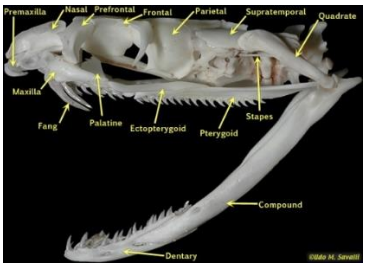


**Figure-Aglyphous Snake Skull. Photo Credit: All You Need is Biology-WordPress*
**Figure-Proteroglyphous Snake Skull. Photo Credit: Udo M. Savalli.*

Aglyphous snakes have several rows of recurved teeth without any special, or modified teeth or venom glands or ducts. They include all boas and pythons, most colubrid snakes, and many other nonvenomous species of snakes. **Solenoglyphous** snakes possess a pair of large, hollow, frontward oriented fangs which fold against the roofs of their mouths when their jaws are closed, and are normally covered by protective layers of sheaths and thin ligaments. These snakes include all pit vipers and other species of viperid snakes. **Opisthoglyphous** snakes, are more commonly known as the "rear fanged" snakes, have one or more pairs of enlarged teeth or fangs located towards the rear of the jaws, or maxillae, which are normally also recurved and are grooved to enable for their venom flow. Some common examples of this group include hognose snakes and false water cobras. Finally, **Proteroglyphous** snakes have a pair of small, unhinged, front-ward oriented fangs located on their front, or anterior maxillae that are hollow, short, and grooved to enable the flow and injection of their venoms. These snakes include the cobras, taipans, mambas, coral snakes, and all other venomous elapid snakes.

**Figure-Solenoglyphous Snake Skull. Photo Credit: Wild View: Wildlife Conservation Society*

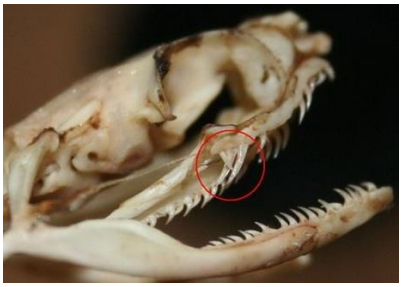


**Figure-Opisthoglyphous Snake Skull. Photo Credit: All You Need is Biology-WordPress*

III. Integumentary System:

The Integumentary System comprises of a snake's outer-most, external organs and organ systems, including their thin layer of underlying skin, hardened, overlapping **scales**, and sometimes other external, keratinized structures such as the rattles on rattlesnakes. A snake's skin and scales serve to provide additional layers of protection from dehydration and desiccation (or water loss), as well as help to prevent external damage or injury, and aid in their overall movement and locomotion. Snake scales can have many different purposes, functions, shapes, and textures, all of which can be used as identifiers in our ability to classify them taxonomically, as well as enhance our ability to identify and distinguish many different species from one another.

**Figure-Keeled/Semi-Keeled Scales on a Snake. Photo Credit: Central Florida's Biologist.*

Some species of snakes have **smooth scales**, while others have tiny ridges or keels on each scale, which are known as having **semi-keeled or keeled scales**, giving them a rougher texture and appearance. A snake's belly, or **ventral scales** or **scutes** are much flatter, and wider overall, enabling them to gain a better grip and traction during movement and locomotion in coordination with their muscular system. These ventral scales then divide into one to two rows of smaller scales, known as **subcaudal scales**, at or slightly past their ventral opening or cloaca, on the undersides of their tails, and can be useful for identification and classification. Contrary to(still) popular belief, snakes are not slimy at all, and have comparatively fewer external glands, so they are not able to "sweat", perspire, or excrete other oils or secretions in the way that

our human bodies do.

**Figure-Smooth Scales on a Snake. Photo Credit: VT Herp Atlas.*

Snakes also have a clear, transparent scale covering each of their eyes, known as a **Spectacle**. Snakes do not
have eyelids or the ability to blink. These clear scales also serve to protect the eye from external

damage or injury, while also retaining water, moisture, and hydration. Snakes can also have tremendously variable scalation along and on top of their heads and jaws. Scales located on the tops of their heads are called **parietal scales**, and may be small and granular, or large and plate-like depending on the species and
taxa. Scales along, behind, and underneath the eyes are known as **ocular, post-ocular, or supra-ocular scales**. Scales located along the upper and/or lower jaws are known as the **Labial Scales**, and scales located at the tip of the snout are known as the **rostral scales**. In many species, all or some of these types of scales can also be highly modified for specific functions or niches, in the form of "horns" or other "appendages". All snake scales, however, are comprised of **keratin**, which is the same material as our hair and nails.

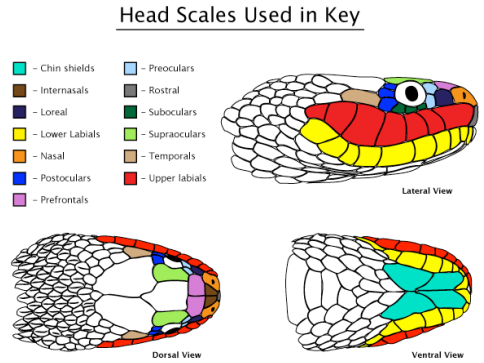


**Figure. Key to the Scalation On/Around the Head of a Snake, including Loreals, Labials, Oculars, Temporals, and Rostrals. Photo Credit: Jonathan Drescher-Lehman.*

Unlike many other animals, snakes and other reptiles also exhibit **indeterminate growth**, meaning they do not stop growing throughout their lives, although their growth rates normally slow considerably once they reach sexual maturity. As a result, snakes and other reptiles must periodically shed their skin. The frequency often depends on their overall age, health, food intake and availability. The more snakes eat, the more they grow, and therefore, the more often they may shed their skin, which is known as **ecdysis**. Snakes and other reptiles can shed their skin several times per year, so determining their age by the number of times they have shed is not reliable. Prior to shedding, a snake's eye-caps will become a milky whitish-blue and appear cloudy. Their skin and scales will form a slightly bluish hue and reduction of color and pattern intensity, which is caused by fluid buildup between their layers of skin and scales.

IV. Muscular System:

All snakes have a well-developed muscular system made up of strong muscles, tendons, and ligaments throughout the lengths of their bodies, skull, and jawbones. A snake's vertebrae, ribs, and overall skeletal system are shaped such that their muscles and ligaments are attached and articulated throughout these points. While humans generally have roughly 700 to 800 muscles throughout our bodies, most snakes have as many as 10,000 to 15,000 or more muscles, allowing them to be much more muscular and flexible than we are! In the case of constricting species such as boas, pythons, and many colubrids, one of the functions of a snake's muscular system is to subdue and overpower their prey. Contrary to popular belief, constrictors do not actually "crush" their prey, or even "suffocate" it. More recent studies have found

that constriction has actually been found to much more efficiently stop or disrupt blood flow to and from the victim's heart, causing cardiovascular collapse.

Perhaps the largest, most well-known purpose of a snake's muscular system is that it assists and enables their movement, locomotion, and overall flexibility. Different species or groups of snakes found throughout the world can have several different forms of locomotion utilizing different muscles throughout their bodies as a result. All snakes use their muscular bodies to grip and push against the surface of the ground and objects around them while exerting force and friction in order to move. All of the different forms of snake locomotion could easily be its own article, and thus will not be covered here.

V. Excretory System:

In snakes, the **kidneys** are the major, or primary sets of organs involved in their Urinary, or Excretory system. As with other organs, snakes have elongated kidneys, and their right kidneys are situated differently from their left kidney. These organs help filter their blood, and remove waste products, which are then concentrated and transported via the **ureters,** hollow tubes designed to transport urine, to their **vent** or **cloaca**, and thus expelled as waste products. **uric acid** is the main form of nitrogenous waste in snakes and most other reptiles. Snakes have lesser amounts of **urea** and **ammonia** than other animals, depending on factors like the environment in which they live and degree of water conservation.

Uric acid produced by the kidneys is excreted by **tubular secretion** in snakes rather than via **glomerular filtration** as in mammals. In mammals, urine is stored in the **urinary bladder** and expelled later through the **Urethra**. Snakes do not have bladders! Therefore urine in snakes is not stored, and the ureters empty directly into the cloaca.

Reproductive System:

All snakes and other reptiles have a reproductive system. This system is comprised of paired gonads, which, in males, consists of the **testes**, and **ovaries** in the females. In females, the ovaries are usually located near their **oviducts**, which carry the eggs to their **uterus** before passing through their Vent or Cloaca. In humans and other mammals, there are typically two ducts associated with each teste (the **epididymis** and **ductus deferen**). Snakes lack the Epididymis, and instead, sperm is simply transported from the teste through the Ductus Deferen to the Cloaca or Vent.

**Figure-Pair of Snake Hemipenes in Male Snakes. Photo Credit: Scott Camazine / Science Source*

Male snakes have a pair of spined or barbed **hemipenes** which are located posterior to the cloacal opening, which act as paired copulatory organs used to transfer the sperm to the female. Both are fully functional, although typically, only one can function at a time. These hemi-penes are typically stored in deep pockets located in the sub-caudal region. In females, which have much shallower pockets, a pair of **scent glands or musk glands** are located in place of the Hemipenes. Some groups of snakes, such as boas and pythons, also possess remnant or vestigial pairs of hind limbs, appearing as **cloacal spurs** located near their Cloacal or Vent opening, which may be larger and more pronounced in males, although large spurs can also occur in females. The primary purpose of these spurs is for stimulating mating and copulation.

VI. Digestive System:

A snake's digestive system is multi-faceted, comprised of several major organs, including the **esophagus**, **stomach**, **small intestine**, **colon**, and **glands**. The esophagus runs adjacent to the air sac from the pharynx, to the stomach. In mammals, the esophagus is very muscular, and moves food directly to the stomach. In snakes, the esophagus has very little muscle and food is moved to the stomach through movements of the body. The junction between the stomach and esophagus is not as well defined and the stomach is less complex than in mammals. A snake's stomach is short and filiform in shape, and contains interior lateral folds to increase surface area for digestion and absorption.

A snake's small intestine is also relatively simple, with a few loops or folds, but is mainly a long tubular organ which receives food from the stomach, absorbs nutrients from it, and transports the remainder to the colon and **Large Intestine.** The colon then carries any fecal or waste matter to the vent or cloacal opening where it is disposed of. The **Liver**, Gall Bladder, and Pancreas are also associated with the digestive system, and play major roles. The liver fills the space between the snake's heart and stomach, and its functions include producing bile and other digestive enzymes. The gall bladder stores bile produced by the liver and releases it into the small intestine when needed. The Pancreas also secretes digestive enzymes into the small intestine, as well as producing other hormones that regulate blood sugar levels.

VII. Lymphatic System:

Unlike humans and other mammals, snakes do not have **lymph nodes**, but they do have a lymphatic system, though it is not as readily located within a snake's anatomy. Snakes do possess a **spleen**, which is relatively small and spherical, located between their **gall bladder** and **pancreas**. In younger, or juvenile animals, it functions in the creation of red blood cells, and in older animals, assists in the destruction of foreign or "unwanted" cells, and blood storage. In most snakes, the spleen is rather tightly adhered to their pancreas, and these two organs may sometimes be collectively known as the "**splenopancreas**".

In snakes, the pancreas is usually located behind the gall bladder and just after the stomach, and is also a major Endocrine System organ. It helps regulate the snake's body blood-glucose levels and helps produce digestive enzymes.

VIII. Respiratory System:
The respiratory system is one of the more prominent organ systems which snakes and other reptiles possess. Beginning with a small opening located on the inside of their mouths called the **glottis**, which opens into the **trachea** (or windpipe). Unlike in humans and other mammals, a snake's or other reptile's glottis is normally held closed in a vertical slit unless the snake takes a breath. A small flap of cartilage located just inside the glottis vibrates when a snake forcibly expels air from their lungs, which produces the characteristic hiss in many different species. Snakes are also able to extend their glottis out one side of their mouths or the other for respiration, which allows them to continue to breathe while swallowing large prey items.

The Trachea is a long, tube or straw-like organ supported by cartilaginous rings, which are separated or divided by thin membranes. It originates at the glottis, and terminates near the heart, where it then branches into two **bronchi**. The left bronchus leads to the **left lung**, which is vestigial, or small, degenerate, and non-functioning in most species of snakes. This left lung can be more well-developed in some more primitive groups of snakes, such as boas and pythons.
The right bronchus leads to the right lung which is elongated and fully functional. The anterior portions of the lung(s) is vascular with blood vessels, and functions in gas and oxygen exchange. The second half of the lung(s) are avascular, or without blood vessels, and is an **air sac** that extends to the tail. This air sac performs a hydrostatic function in most snakes by regulating air pressure inside their body cavities. Since snakes do not have a **diaphragm**, air enters and leaves the lung due to movement, contracting, and relaxation of their ribs and bodily muscles instead. Inspiration is an active process therefore (where muscles contract), while Expiration is passive (where muscles relax). There is also no exchange of respiratory gasses.

IX. Nervous, or Neurological System:

As with all vertebrate animals, snakes possess a well-developed nervous, or neurological system. Their **Brain** is elongated and consists of several portions, most notably a forebrain and a **brain stem** (consisting of a mid-brain and hind brain). The most significant difference between a snake's brain and those of mammals or birds is the presence of a **dorsal ventricular ridge** in the Telencephalon of the forebrain. The auditory portion of their mid-brains has been found to be more well-developed than previously believed. The optic lobes of their midbrain receive their primary input from their eyes and secondarily from their olfactory and auditory centers, better known as their **Jacobson's organ**.

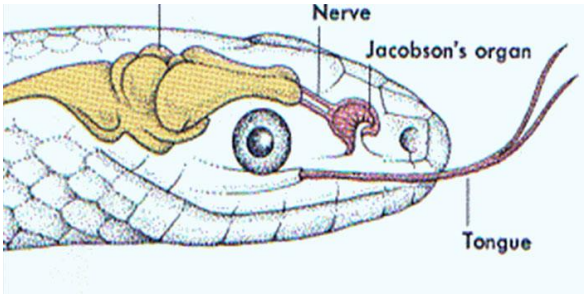


**Figure-The Snake Brain and Jacobson's Organ. Photo Credit: ReptileKingdoms.*

All snakes, and other reptiles, possess a **spinal cord** extending the length of their

vertebral columns, which give rise to differing segments and nerve endings at each vertebral segment that are able to act as mechanoreceptors. These segments can have dorsal, or sensory, and ventral, or motor roots. There have been long-standing questions regarding, the pain perceptions in reptiles when compared to humans and other mammals. As a result there are several dissenting theories when it pertains to a snake's, or reptile's nervous or neurological system. One proposes that the nerve endings able to sense and detect heat are different from those which detect pain. Some believe this is because their pain receptors and nerve endings are less developed compared to other vertebrates. Other theories into this area may have to do with a snake's "learning theory" and the necessity of these receptors throughout their evolution. Regardless of the theory, there still remains much to be studied when it comes to a snake's overall level of pain reception and neurological system.

X. Endocrine System:

Snakes, as well as other reptiles, do have a pituitary, or endocrine system, although its actions and metabolism generally tends to be much less known and understood when compared to mammals. Snakes possess a single **thyroid gland** which is roughly spherical, and is enclosed within a connective tissue capsule. It is cranial to the heart, and ventral to the trachea.

The thyroid gland is believed to play an important role in their overall shedding and growth. Other glands generally occur in pairs located at varying points along their bodies. The **thymus, parathyroids** (which play the most important role in calcium metabolism), and **adrenals** (located near the base of their tails and cloaca, which secrete epinephrine) are examples. **Pituitary glands** play only minor roles, and can have significant differences in their location and morphology depending on the species, but otherwise generally have similar functions to those in mammals and other vertebrates.

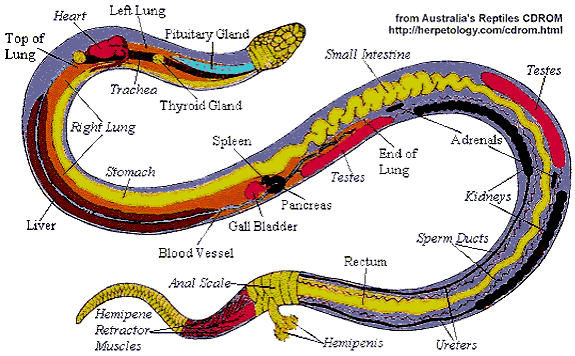
The **pancreas** is also present and can vary considerably in its exact location and anatomical relationships depending on the species. As with mammals and other vertebrates, the Pancreas is both an exocrine and endocrine organ. In some genera or taxa, the islet tissue is formed into large, or giant islets rather than scattered randomly throughout.

XI. Cardiovascular System:

Unlike in humans and other mammals, which have four chambered **hearts**, two atria and two ventricles, snakes have three chambered hearts consisting of two atria, and one ventricle. The left and right atria of their hearts receive blood from their lungs and body, and transfer it to the ventricle to be circulated again. The left atria receives the oxygenated blood, while the right atria receives de-oxygenated blood for circulation. The heart is also enclosed in a thin sac known as the **pericardium**, and the heart is generally located anteriorly within the body at the juncture of the bronchi, although it can also move around due to a snake's lack of a diaphragm, making it difficult to precisely locate. This flexibility in movement provides protection to the heart and prevents its damage when large prey items are ingested.

Other organs within a snake's cardiovascular, or circulatory system, which filter blood and recycle red blood cells include the Spleen, gall bladder, and pancreas. The thymus gland, located within the fatty tissue above the heart, is responsible for the maturation of special immune cells in the blood, as well. According to Mader's Reptile Medicine and Surgery (2005), there are also two aortae, or **arteries** which exit the heart. The right aorta exits from the left side of the ventricle and the left aorta from the right side. The aortae join caudally to the heart to form the abdominal aorta that extends caudally

through the coelomic cavity. The left systemic arch is larger than the right, unlike humans and most other animals.



**Recap Figure-Overall Internal Organs and Organ Systems of a Snake. Photo Credit: Australian Reptiles CDROM.*