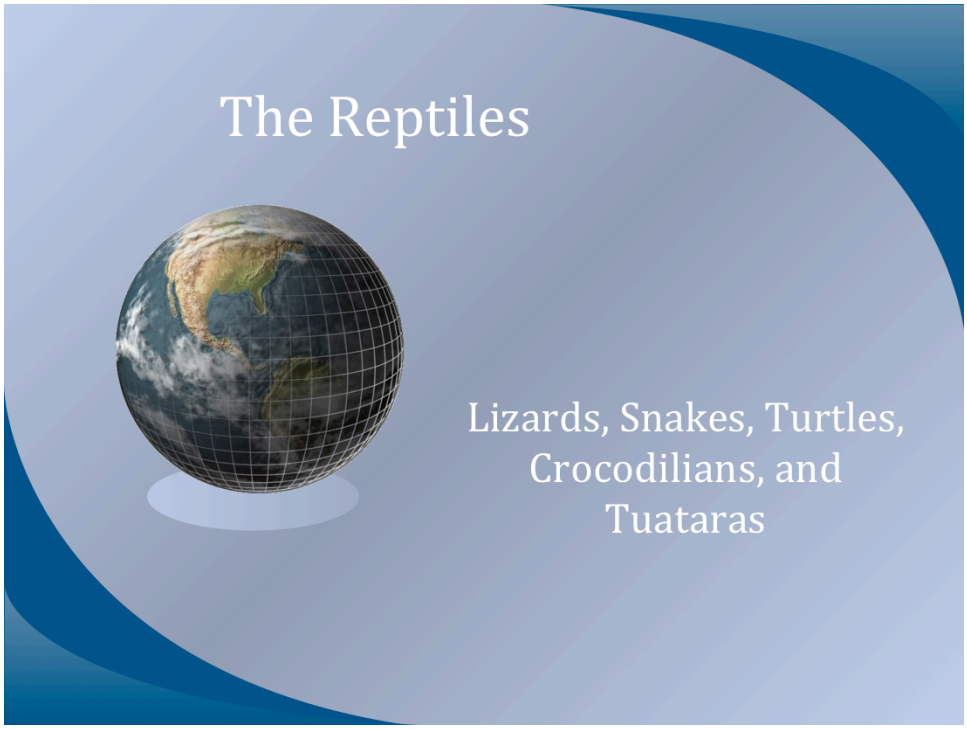
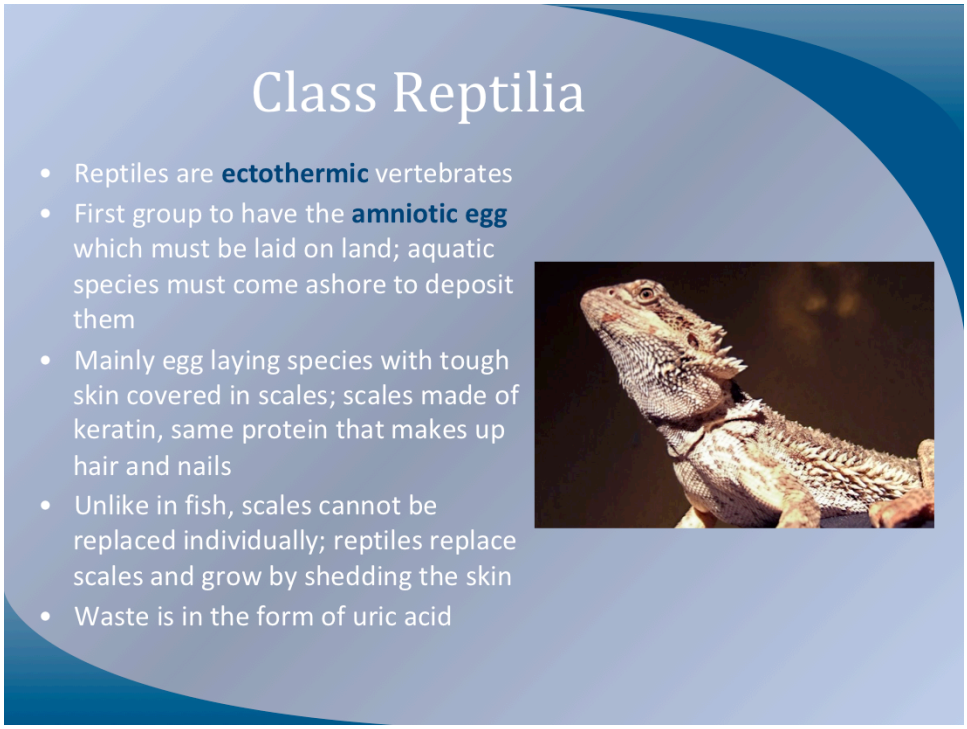


A reptile is a Class of vertebrate animal that includes snakes, lizards, crocodiles, turtles and tortoises. They are distinguished by having a dry scaly skin and typically laying soft shelled eggs on land.

Reptiles evolved from amphibians about 312 million years ago and became adapted to living on dry land due mainly to the amniotic egg.

Reptiles are differentiated from amphibians by:

- Evolution of stronger, more effective jaw mechanisms
- Evolution of more effective locomotion on land
- Development of the amniotic egg
- Development of scales for water tight skin



Reptiles are **ectothermic,** meaning they are "cold blooded" and regulate their body temperature with the aid of an external source such as sunlight. Reptiles use the ability to shift blood between the body and the lungs to accelerate heating and slow cooling.

They were the first group to have the **amniotic egg**, meaning the embryo is encased in a **semipermeable** shell. Reptile eggs must be laid on land so aquatic reptile species must come ashore to deposit them. The shell , which has a leathery texture, keeps the embryo within the egg from drying out. Young reptiles develop inside an egg, cushioned in a bag of fluid called the amnion. A yolk provides the animal with food, while oxygen and moisture are absorbed through the eggshell. Some reptiles lay eggs while others give live birth.

Reptiles are mainly egg laying species with tough skin covered in scales or scutes. Reptile scales may be small and overlapping as in many lizards, or large and adjoining as in turtles where they are commonly called scutes. The skin, scales and scutes are made of keratin and provide a water tight covering for the reptilian body. Keratin is the same protein that makes up hair and nails. Unlike fish, reptile scales cannot be replaced individually. As reptiles grow, scales are replaced as they shed their outer layer. Reptiles shed in pieces, whereas snakes shed in one large piece, kind of like taking off a sock. Molting permits the replacement of old, worn outer layer of skin, disposal of parasites such as mites and ticks and allows the snake to grow continually throughout their life.

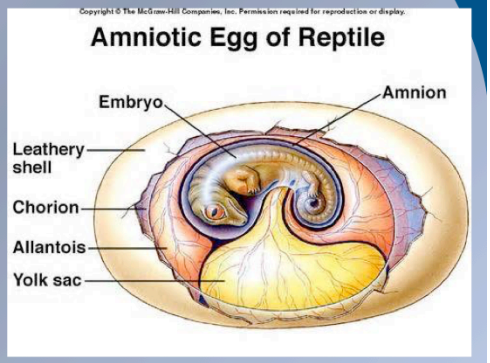
Reptiles are better adapted to locomotion on land than amphibians. Reptiles have a sprawling posture with legs splayed out to the sides of the body trunk. In walking or running, they twist first to one side and then to the other. The tail provides balance and acts as a counter-weight.

All reptiles except crocodilians have a heart with a single ventricle. The three-chambered heart can adjust the proportion of blood that goes to the body versus the lungs. Reptiles use the ability to shift blood between the body and the lungs to accelerate heating and slow cooling. The three-chambered heart of reptiles limited its ability to breath while chasing down prey and hence were ambush predators. The fourth chamber of the heart improved the crocodiles ability to actively hunt down prey.

Generally in reptiles, teeth are simple and conical (peg-like) and they are similar in shape and size throughout the jaw (homodont). Reptile teeth are continuously shed and replaced throughout the life span, and the upper and lower tooth rows do not contact one another. They are used for killing and holding. Reptiles swallow their food whole. Waste is passed in the form of uric acid, which is low in water content. Uric acid has the advantages of reducing water loss

The Amniotic Egg: A Giant Step In Evolution

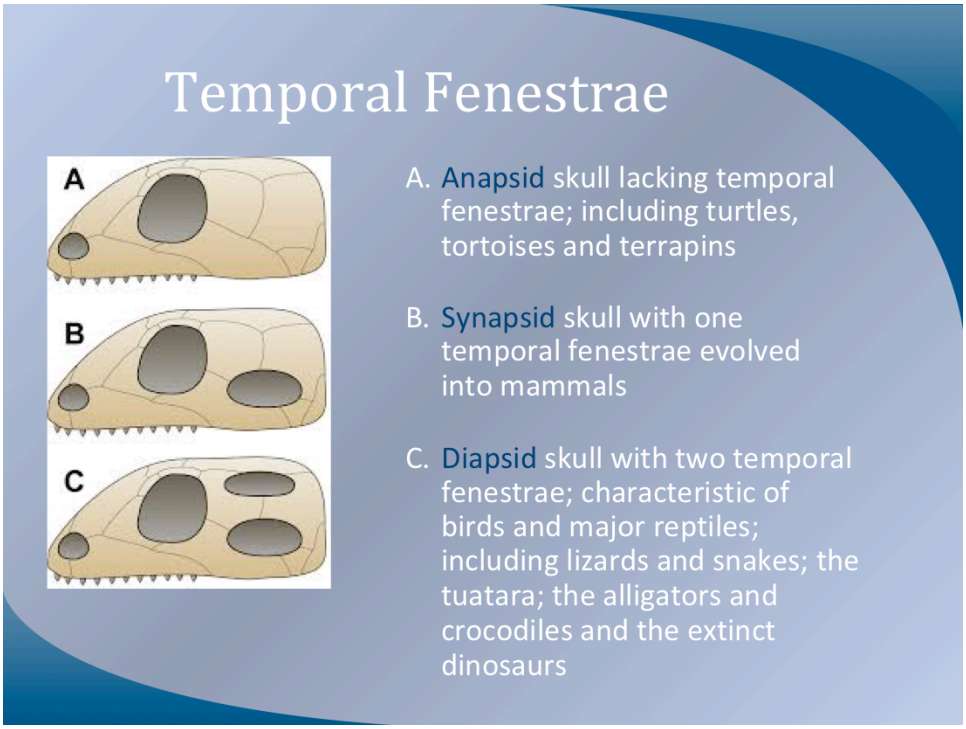
- A tough outer shell protects the egg from predators, pathogens, damage, and drying
- A semi-permeable shell allowing for gas exchange whilst still retaining essential fluids like water
- The yolk inside the egg feeds the embryo until hatching
- Reptiles, birds, and mammals all have amniotic eggs



The significance of the evolution of the amniotic egg is that reproduction no longer had to take place in water. Animals emerged from the oceans to life on the land. Eggs could "breathe" and cope with wastes, eliminating the need for a larval stage thereby allowing the embryos to evolve into larger forms and mature further prior to hatching.

Adaptive advantages of an amniotic egg include: a tough outer shell which protects the egg from predators, pathogens, damage, and drying, a semi-permeable shell that allows for gas exchange while still retaining essential fluids like water, and a yolk inside the egg which feeds the embryo until hatching.

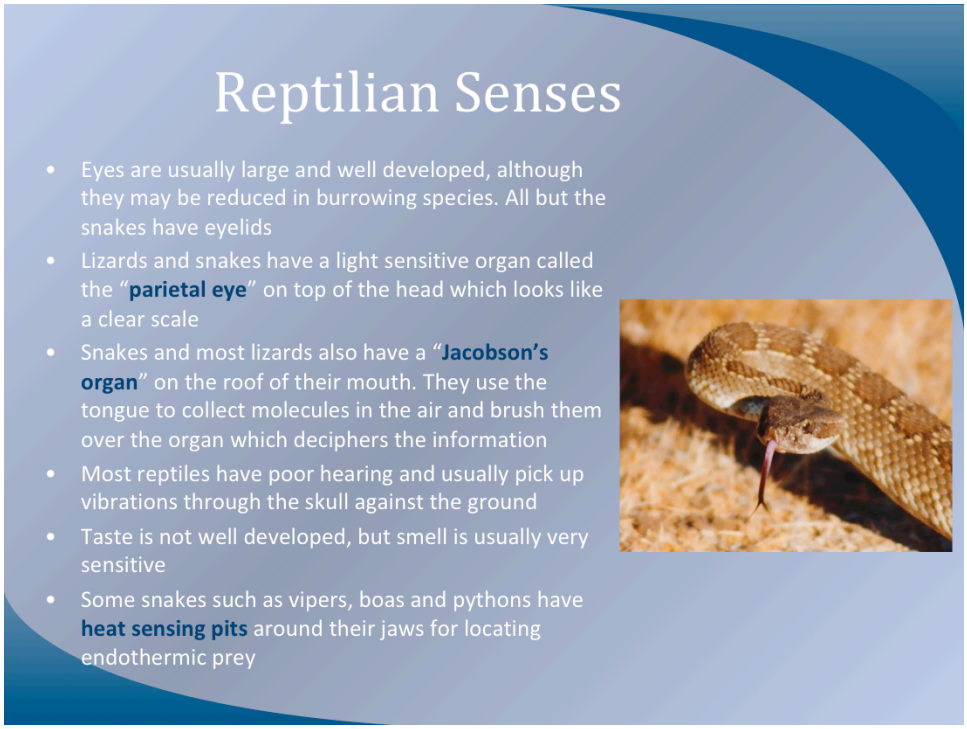
Animals were no longer tied to life in the oceans. Animals could live and reproduce on land for the first time. Thus organisms could radiate across terrestrial environments carving out new niches.



Very early in reptile history, changes to ancestral condition occurred in the nature of muscle attachment to the lower jaws and the skull. These changes had to do with the development of stronger and more efficient jaw muscles and a diversification in what they ate. Early diversification of amniotes produced three patterns of holes in the **temporal** region of the skull, just behind the eye. These openings, or **fenestrae**, provided space for the large muscles needed for feeding when shifting from an aquatic environment to a terrestrial one where the vegetation was more coarse. Modern reptiles are split into four subclasses based on the number and position of temporal fenestrae, openings in the sides of the skull behind the eyes. Fenestrae allowed for the attachment of larger, stronger jaw muscles resulting in more powerful and faster bites.

The important thing to know about this slide is that reptiles are classified according to their (or lack of) temporal fenestrae. Most modern reptiles have two fenestrae with the exception of the turtles, tortoises, and terrapins, who lack fenestrae. The synapsids evolved into modern mammals.

Other characteristics of the reptile's skull is the teeth are more or less uniform in size and shape (**homodontic**); they vary slightly in size, but they all have the same basic cone-shaped/peg-like form. The lower jaw is composed of several different bones, which hinge on the **quadrate** bone of the skull and the angular bone of the jaw. In reptiles, there is only one bone of the middle ear, the stapes. The reptilian skull is attached to the spine by a single point of contact, the **occipital condyle.**



Reptilian eyes are usually large and well developed, although they may be reduced in burrowing species. All but the snakes have eyelids.

Lizards and snakes have a light sensitive organ called the "**parietal eye**" on top of the head which looks like a clear scale and is associated with the pineal gland. The parietal eye detects changes in light, and allows the animal to properly **thermoregulate,** manage their heat. It acts as a defensive measure, since an approaching predator will cause the light to change.

Snakes and most lizards also have a **Jacobson's organ** on the roof of their mouth. They use the tongue to collect molecules in the air and brush them over the organ which deciphers the information. The longer the tongue's fork, the more precisely the reptile can the decypher the location of the scent. The ability to interpret the molecules in the environment is extremely developed in snakes & lizards. **Note:** young kids find it interesting to learn that a snake can enhance its smell with its tongue.

Most reptiles have poor hearing and usually pick up vibrations through the skull against the ground.

Taste is not well developed, but smell is usually very sensitive.

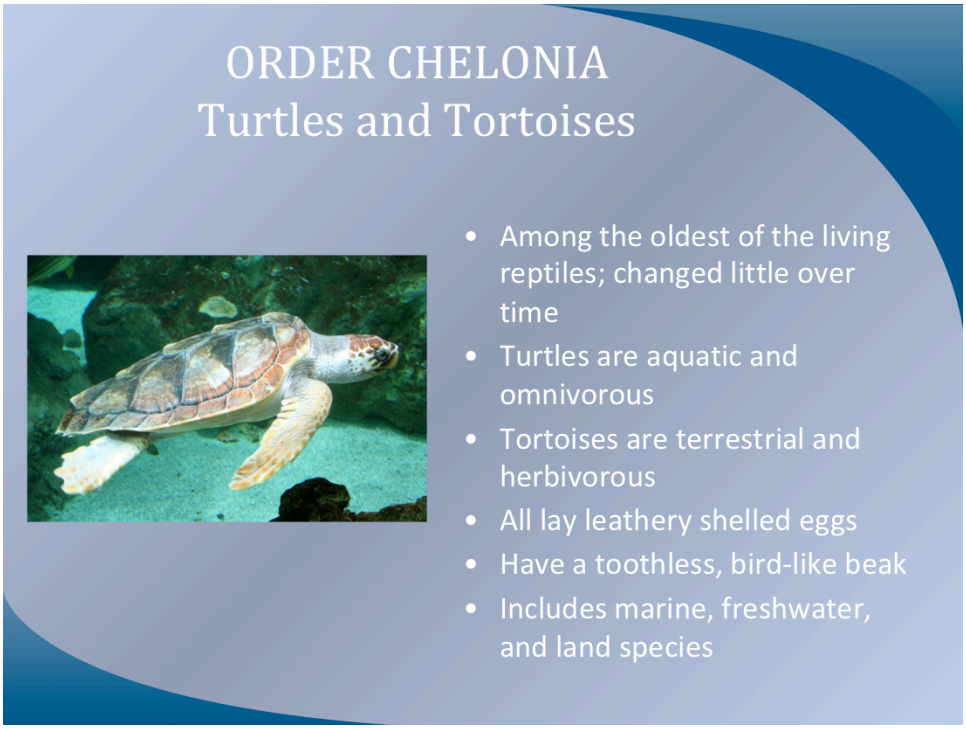
Some snakes such as vipers, boas and pythons have heat sensing pits around their jaws for locating endothermic prey, such as small mammals.

The development of amniotic eggs freed animals from having to deposit their eggs in the water, but it came at a cost: External fertilization of shelled eggs is not possible. The shell of a reptile's egg is impervious to sperm, so the eggs must be fertilized before they have formed this layer and are deposited. Internal fertilization developed for reproduction in reptiles.

Reptiles show a great variety of reproductive strategies; **ovipary**, which is external egg laying; **ovovivpary**, where eggs are maintained internally and the young hatch in the female and are then "born", but also **vivipary**, which is a live birth with a primitive placenta like structure, and even parthenogenesis is seen in several lizards and one snake species. **Parthenogenesis** is a form of asexual reproduction in which growth and development of embryos occur without fertilization. Female Komodo dragons can produce offspring by parthenogenesis when no male is available for sexual reproduction. These offspring produced in this way are all males. The zoo's Komodo dragon was a parthenogenic birth.

Many species, especially snakes, have young that have very different coloration from the adult form. For example, the emerald tree boa generally have brown young and the adult is green. Also, parental care is rare except in the crocodilian group.

All reptiles, such as the snake and turtle reproduce by internal fertilization. Males and females usually have one opening through which semen, urine and feces can be released.



The turtles and the tortoises are among the oldest of the living reptiles; these species have changed little over time. Turtles and tortoises are some of the longest living vertebrate species; it is not uncommon for larger species to live over 100 years. Terrestrial species are referred to as tortoises, while aquatic species are turtles. Both turtles and tortoises completely lack teeth.

Beginning as semi-aquatic marsh dwellers, the tortoises evolved to become totally terrestrial. In order to lower energy cost for locomotion, they developed lightweight shells. Their shells became high-vaulted so that tortoises could retract them in defense against predators. Since tortoises are slow on land, they developed sharp ridges instead of teeth and became almost entirely vegetarian.

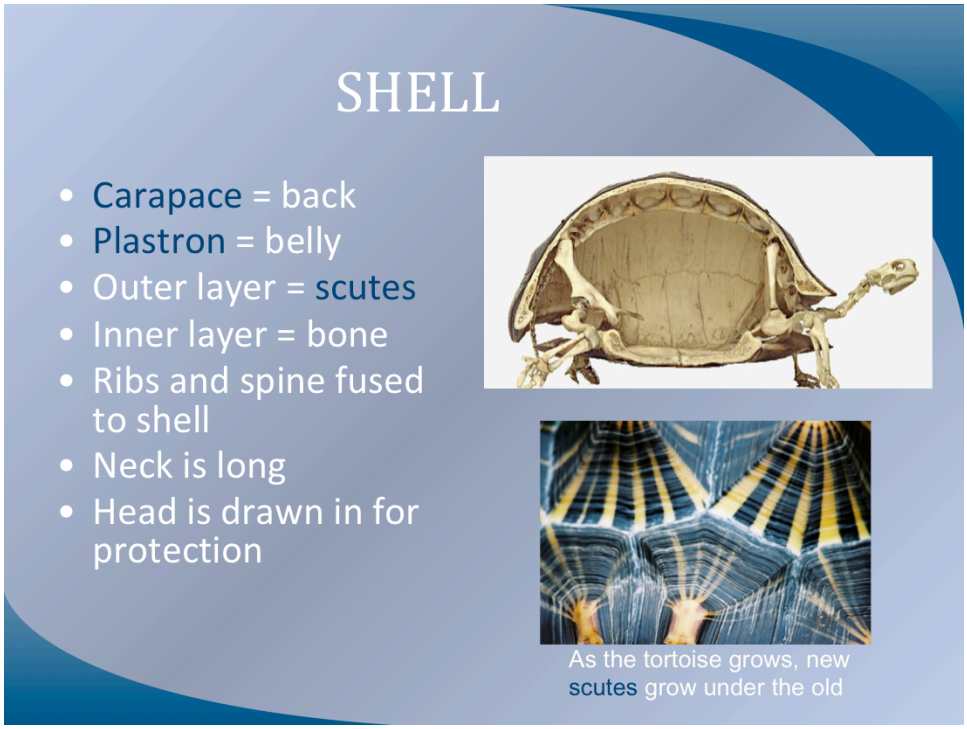
As turtles became more aquatic, the bones of their shells decreased in size making them more buoyant. They also developed lower, more streamlined shells that offered less water resistance during swimming. Turtles can breathe through lungs, lining of the throat, skin, and thin-walled sacks in the cloaca.

Many turtles have special strategies and techniques for obtaining food. One method is ambush, where the turtle lies in wait rather than pursuing its prey. Ambush feeders, like the snapping turtle, have long muscular necks that can strike out for prey at some distance. Another method of feeding is “gape and suck”. By quickly opening their mouth and simultaneously expanding their throat, suction is created, which can pull small food items into the waiting turtle’s mouth.

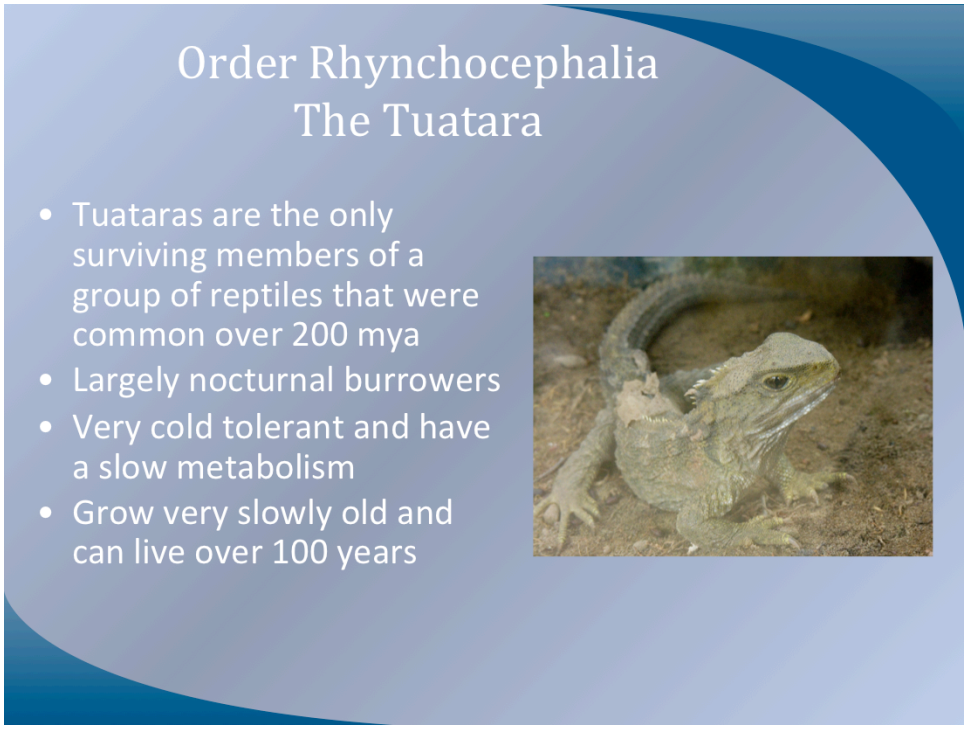
Turtles and Tortoises all lay leathery shelled eggs. Research has indicated that the majority of the world’s turtles have temperature dependent sex determination.

The limbs of a turtle or tortoise are good indicators of their habitat and means of locomotion. Tortoises have elephantine feet, in which the toes are very short and lack all traces of webbing. The feet of the aquatic turtles differ by having longer toes joined together by a fleshy membranous web providing the feet with additional thrust through water. Aquatic species can also breathe through their skin, the lining of their throat, and through thin-walled sacks in the cloaca.

The Zoo has red-eared slider turtles in the children’s zoo and a desert, leopard and radiated tortoise in the ARC. The Zoo is involved in a western pond turtle conservation project. The western pond turtle is one of three native California turtle species. The Sculpture Learning Plaza has a leatherback sea turtle.



All turtles and tortoises have a hard shell that encases the soft body where they can partially or entirely cover the head and feet by pulling into the shell. The shell consists of two parts; a **carapace** that covers the animal's back and a **plastron** that covers its belly. The shell is part of their skeleton with the ribs and backbone fused on the inner surface, which is bony. The shell is made of an outer layer of horny shields called scutes, and an inner layer of bony plates. The scutes and plates are made of keratin. The shell provides good armor against predators. Unlike popular belief and depictions in cartoons, turtles cannot leave their shell.

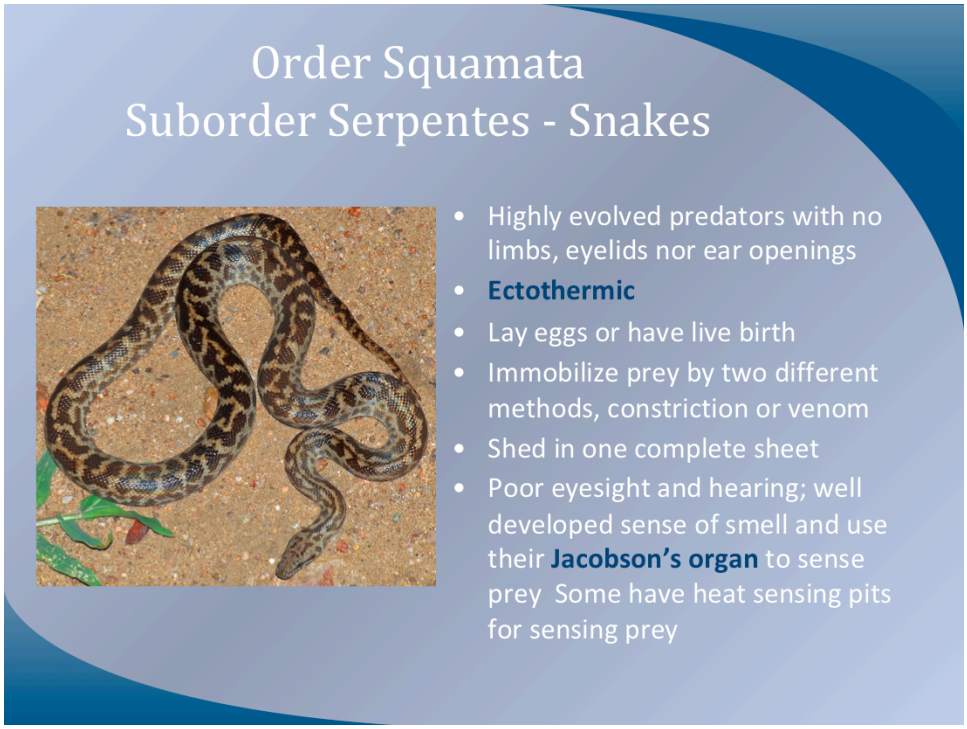


Tuataras are the only surviving members of a group of reptiles that were common over 200 million years ago. They are found only on islands off the coast of New Zealand. The tuatara has been re-introduced onto the North Island in a reserve. Before man, the tuatara was common on both the North and South Islands, but went extinct on the main islands due to invasive species such as rats, who ate their eggs.

Unlike lizards, tuataras are largely nocturnal burrowers, are very cold tolerant, have a slow metabolism and may only breathe once an hour when resting. They grow very slowly and are not sexually mature until 20 years old and can live over 100 years.

Why do you think the tuatara has no external ears? This may be an adaptation to two things- they are a burrower and appendages may interfere with them moving underground efficiently. They also like cooler temperatures and you will typically see smaller appendages on animals in cooler environments. The smaller the appendage, the less surface area that the animal will loose its body heat.

The Sculpture Learning Plaza has a tuatara.



Snakes are highly evolved predators with no limbs, no eyelids nor ear openings. They do have a scale on their eye for protection, called a **brille**. Scales on their body serve to reduce friction as the snake moves; the ventral (or belly) scales, which are large and oblong, are especially low-friction. They are **ectothermic.**

Depending on the species, snakes immobilize prey either by constriction or venom. **Constsrictors** coil tighter with each movement of the prey. This continues until there is no movement. The coils around the prey's chest compresses the heart and deflates the lungs, leading to heart attack and suffocation. Venomous snakes deliver venom through their fangs. Venom typically attacks the nervous system (neurotoxin) but can also affect blood cells and clotting (hemotoxin) and the muscles of the heart. Venom is not meant for defense but as a way to immobilize prey and aid in digestion. Of the approximate 2700 snake species, roughly 600 are venomous. Most advanced venomous snakes can fold their fangs up into the jaw. This will prevent the snake from puncturing the bottom of its own mouth.

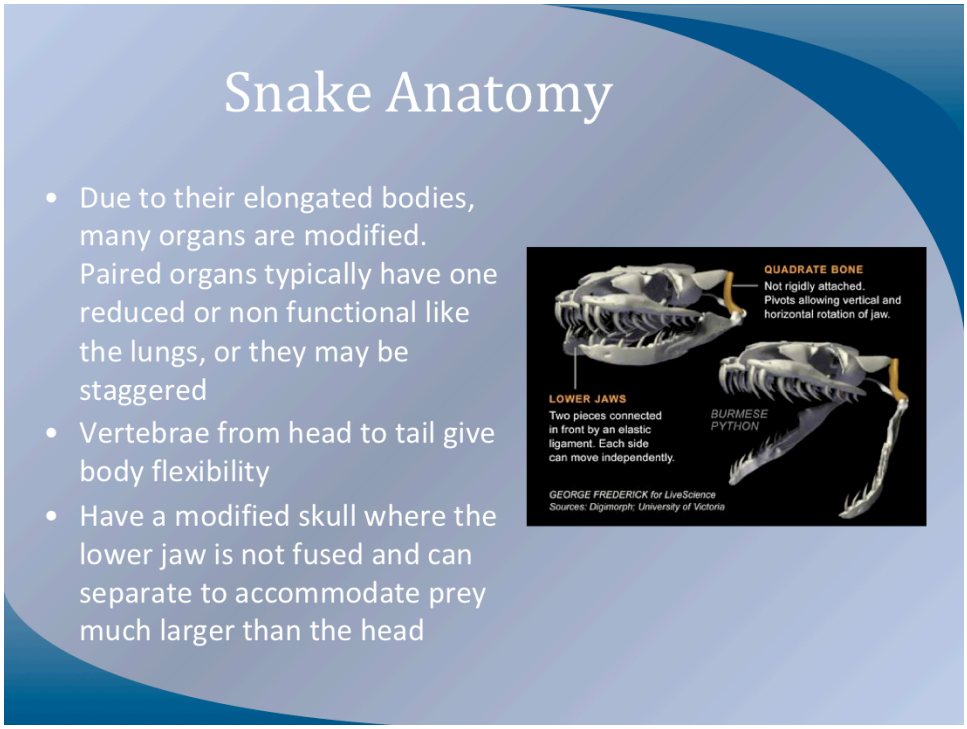
Note: The real difference between a toxin being a venom or a poison involves how that toxin is delivered; when a toxin is delivered into an organism through injection (e.g. snake bite), it is called a venom. If the toxin is delivered by touch or ingestion, it is called a poison. Some snakes are venomous. Some frogs are poisonous.

Snakes have poor eyesight and hearing; their sense of sight varies greatly, and they appear to recognize movement more readily than shape or form. Diurnal snakes have pupils they can close tightly to allow a minimum amount of light in whereas nocturnal snakes have pupils that can open wide to allow for a maximum amount of light.

Snakes do have a well developed sense of smell using their chemical receptor laden forked tongue to collect airborne molecules. The forks of their tongue are then inserted into the opening ducts of the **Jacobson's organ**, the molecules are identified, and the information is passed along to the brain. The fork in the tongue allows the snake to determine the direction from which a scent is coming.

Snakes are able to feel vibrations from the ground. Pit vipers, pythons, and some boas have heat sensing pit organs in deep grooves between the nostril and eye, which allow them to detect infrared thermal radiation from potential prey; they can "see" the radiated heat of warm-blooded prey mammals.

The Zoo's Tropical Building has a green anaconda, emerald tree boa, amazon tree boa, and a red-tailed boa. The Sculpture Learning Plaza has a rattlesnake and a Burmese python.



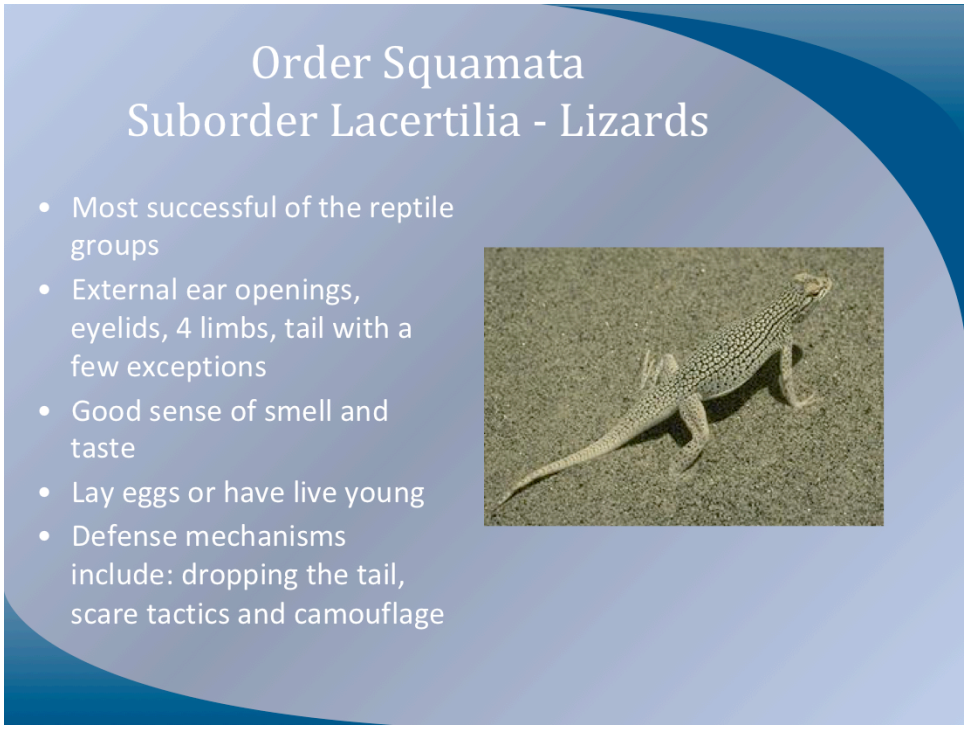
Snake backbones are flexible with 180 to 400 vertebrae. Due to their elongated bodies, many organs are modified in the snakes; organs are long and thin. Paired organs typically have one reduced or nonfunctional like the lungs, or they may be staggered. Boas and pythons retain a full pair of lungs.

Snakes are limbless but in the more primitive boas and pythons, remnants of the hind limbs project as a horny spur on either side of the cloaca.

The skull is modified; the lower jaw is not fused and can separate to accommodate prey much larger than the head. The left and right sides of the lower jaw are joined only by a flexible ligament at the anterior tips, allowing them to widely separate. The upper jaw connects to the lower jaw by the **quadrate bone,** which works like a double-jointed hinge allowing the mouth to open as wide as 150 degrees.

The bones of the mandible and quadrate bones can also pick up ground borne vibrations. Because the sides of the jaw can move independently of one another, snakes resting their jaws on a surface can sense vibrations which help detect the position of prey.

Note: It is a common misconception that snakes dislocate their jaws to eat. Snakes just have the ability to open their jaws very wide, due to the quadrate bone, stretching skin and the separate lower jaws.



Lizards are the most successful of the reptile groups. They have external ear openings, eyelids, four limbs, and a tail with a few exceptions. Some species can break off their tails at stress points along the vertebrae to escape predators. They have the ability to regenerate the tail tissue, although it will not be as uniform as before and will not contain bone.

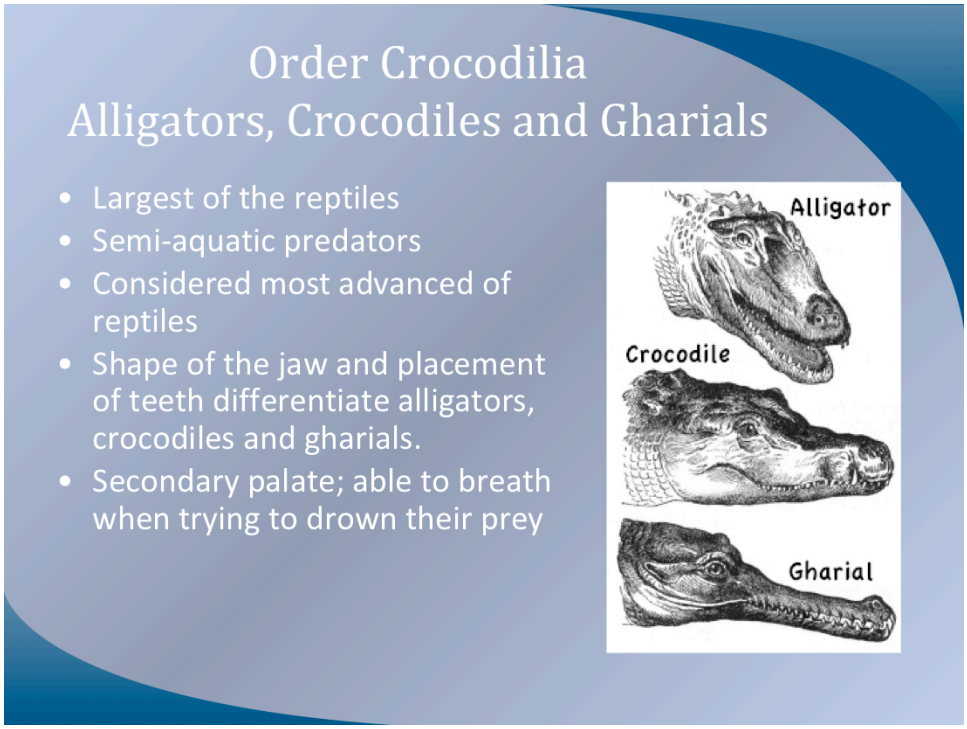
Note: Snakes are differentiated from lizards in that they have no eyelids whereas the lizards do.Tuatara are differentiated from the lizards in that they have no external ears, they prefer cooler weather and are nocturnal.

Lizards have a good sense of smell and taste. Some lizards, like monitors, have a **Jacobson's organ** that makes their sense of smell even more acute.

Lizards can hear better than a snake, but not as well as humans. Some geckos produce chirps or clicking noises when mating or defending territory, but most lizards do not vocalize.

Diurnal lizards have a good sense of sight. Most lizards have eyelids, but some species, have a clear membrane that shields their eyes from dirt and bright sun.

SF Zoo has several species in the ARC, including geckos, a legless lizard, and bearded dragon. The Zoo has a Komodo dragon, plumed basilisk and other reptiles in the South American Aviary. The Sculpture Learning Plaza has a Galapagos marine iguana, and a panther chameleon.



Crocodilians are the largest reptiles and have changed little since the time of the dinosaurs. They are the onely living reptilian representatives of the archosaurian lineage that gave rise to the extinct dinosaurs and living birds. They are top predators and are often keystone species, though they also contribute to the food chain as prey whilst they are still young.

Alligators and caimans are found in the Americas and crocodiles and gharials are mainly Asian, African, Australian, with a few Central and South American representatives.

Alligators (upper photo) and caiman have wide, rounded snouts with only the upper teeth overlapping out of the jaw. Crocodiles (middle photo) have pointed snouts with both upper and lower teeth visible with the mouth closed. The teeth of the crocodilians are socketed with deep roots like those of humans.

Gharials (bottom photo) have long, narrow snouts with needle like teeth for catching fish. They are one of the longest of all living crocodilians. Gharials lack the strength of the skull and jaw that most crocodiles and alligators have, and consequently are unable to prey on larger creatures. The reduced weight and water resistance of their lighter skull and very narrow jaw enables gharials to catch rapidly moving fish, using a side-to-side snapping motion.

Crocodilians display adaptations for a carnivorous, semi-aquatic life, including a massive skull with powerful jaws and a secondary palate; their eyes, nose and ears, external sensory organs, are high on their head and remain out of the water when the rest of the body is submerged. **Note:** the hippo and green anaconda also have their external sensory organs high on their heads and spend a large part or their time mostly submerged with their head out of the water.

Crocodilians are considered the most advanced of the reptiles with a four-chambered heart, diaphragm, and cerebral cortex. The **secondary palate** is an anatomical structure that divides the nasal cavity from the oral cavity in many vertebrates. This structure enables them to breathe when partially submerged, even if the mouth is full of water or if it is full of food. **Note:** the secondary palate is thought to have a significant role in the development of mammals because it enables an infant to suckle and breathe at the same time.

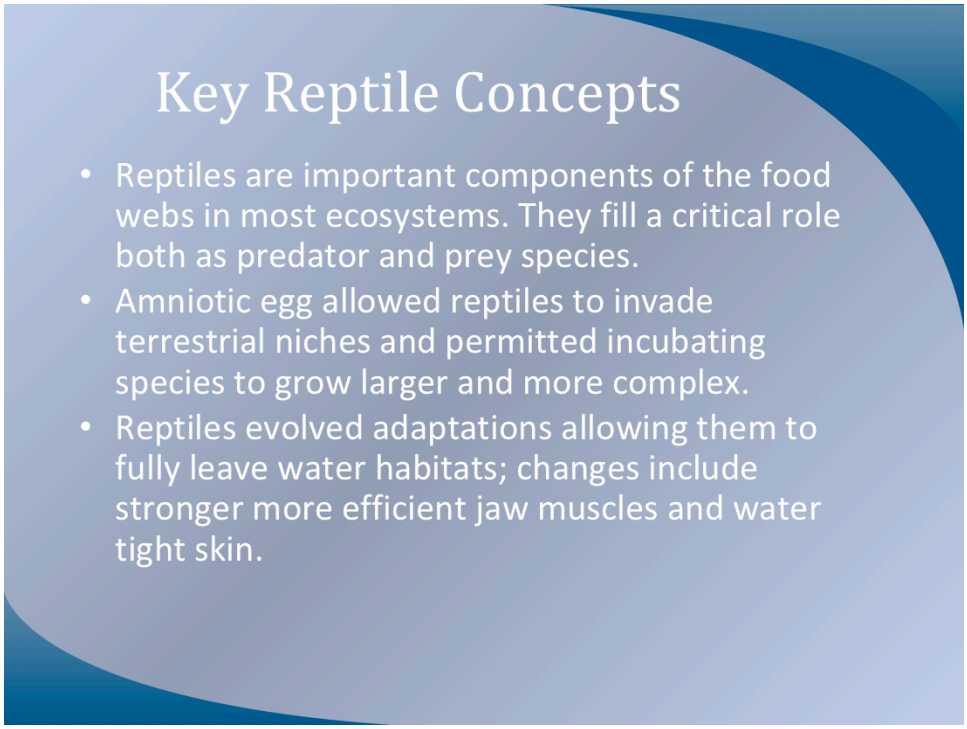
Crocodilians have the most complex social behavior of any living reptile. There is some parental care as they tend to both their eggs and hatchlings. Like other reptiles, the sex of their offspring is temperature dependent.

The Sculpture Learning Plaza has a salt water crocodile.

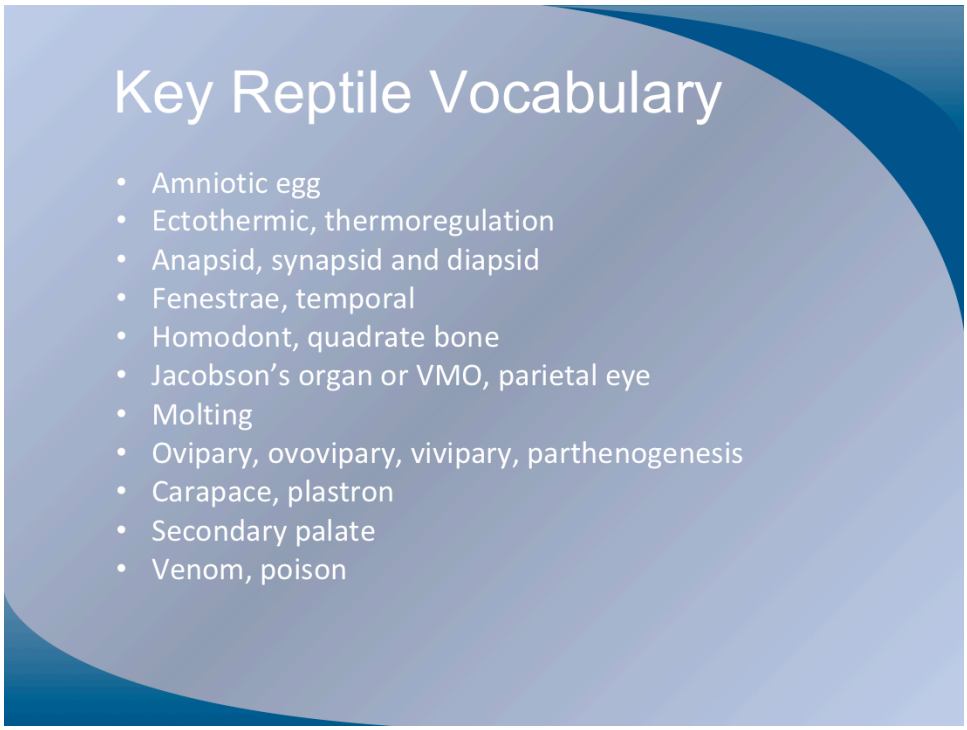
Reptiles have suffered from a broad range of human activities, due in part to the perception that these animals are either dangerous or of little environmental or economic value. There is a lot of fear surrounding snakes and other reptiles. What you might not realize is that reptiles do a lot of good. For example, snakes eat rats and other small animals. Rats can carry diseases to people, so keeping their population under control is very important. We know now that they are important parts of our natural and cultural heritage.

All crocodilians, sea turtles and Boidae (boas and pythons) are included in CITES Appendices I or II, due partially to their exploitation as pets and consumer products. Reptiles are not recommended as pets. Some are taken from the wild and they require specialized care (food, lighting, heating, exercise, long-lived, difficult to find a vet).

Western Pond Turtles were once plentiful and ranged from as far south as Baja, California to as far north as British Columbia. They are the only aquatic turtle on the West Coast. The zoo is giving them a head start to help restore their populations. After hatching in the zoo, they are raised to a larger size than they would be in the wild and have a better chance of surviving.



Corresponds with the Reptilia, Crocodilia, Lizard, Snake & Turtle Study Guides found in the Docent Notebook. For specifics on the zoo's reptile collection read the Reptilia Fact Sheets in the Docent Notebook or got to the SF Zoo's website (sfzoo.org)



Definitions:

Amniotic egg: Shell which encases a developing embryo that can be deposited on land instead of water.

Anapsid: the skull does not have openings near the temples; no temporal fenestrae.

Carapace: the upper or dorsal shell of the turtle

Diapsid: having two openings in the skull behind each eye;

Ectothermic: any animal whose regulation of body temperature depends on external sources, such as sunlight or a heated rock surface

Fenestrae: a small opening in the bone

Homodont: having one kind of tooth

Jacobson's Organ, an organ of chemoreception that is part of the olfactory system of amphibians, reptiles, and mammals

Molting: periodic shedding of ones outer covering to make way for new growth.

Ovipary: method of reproduction in which eggs are laid and embryos develop outside the mother's body

Ovovipary: method of reproduction in which the embryo develops in the maternal body but hatches only after extrusion of the egg. The embryo is not nourished by food from the mother.

Parietal eye: known as a third parietal eye or pineal eye, is photoreceptive and is associated with the pineal gland, regulating circadian rhythmicity and hormone production for thermoregulation

Parthenogenesis: form of asexual reproduction in which growth and development of embryos occur without fertilization

Poison: a substance that is ingested or spread by touch that is capable of causing the illness or death.

Plastron: the ventral or bottom shell of the turtle

Secondary palate: an anatomical structure that divides the nasal cavity from the oral cavity in many vertebrates.

Semipermeable: The ability of molecules to pass through a membrane.

Synapsid: having one opening in the skull behind each eye.

Temporal: of or relating to the temples; situated on the side of the skull and containing the organ of hearing

Thermoregulation: the ability for an organism to maintain its core internal temperature independent of the temperature of the environment.

Venom: a poisonous substance secreted by animals such as snakes, spiders, and scorpions and typically injected into prey or aggressors by biting or stinging.

Vivipary: development of the embryo inside the body of the mother, eventually leading to live birth, as opposed to laying eggs