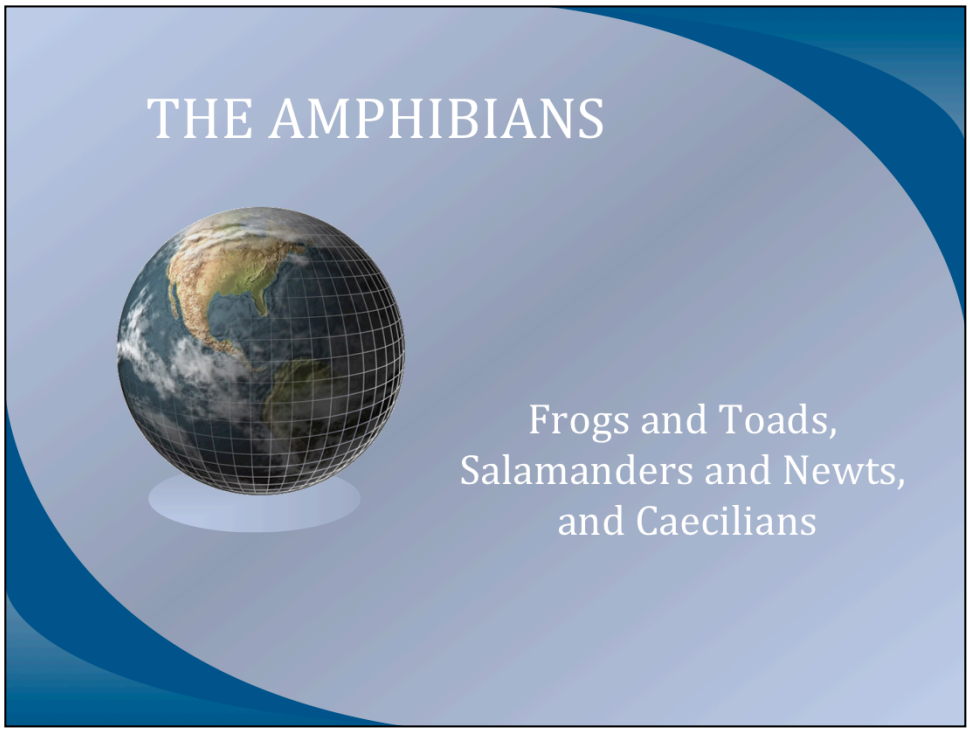
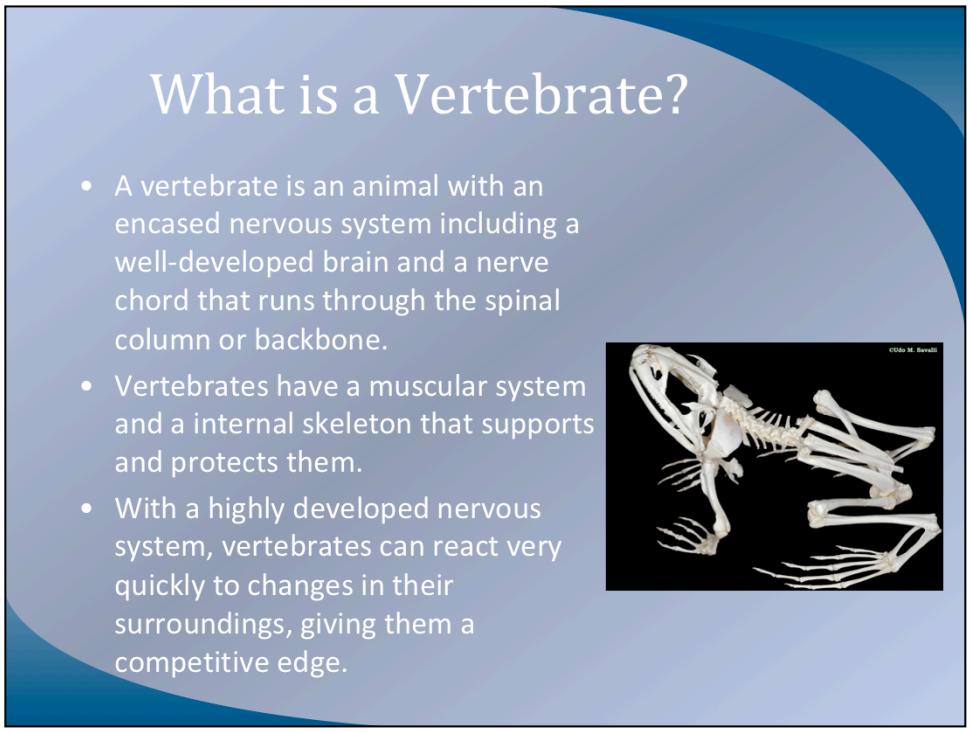


Amphibians were the first Class of vertebrates that stepped out onto land and were the only vertebrate life forms on earth for about 60 million years. In order to successfully transition onto land, an animal must withstand the effects of gravity, must breath air, must minimize water loss and must be able to move about the land and adjust their senses to air instead of water.

Amphibians evolved adaptations that allowed them to stay out of the water for longer periods. Their lungs improved and their skeletons became heavier and stronger, better able to cope with the increased gravitational effect of life on land.

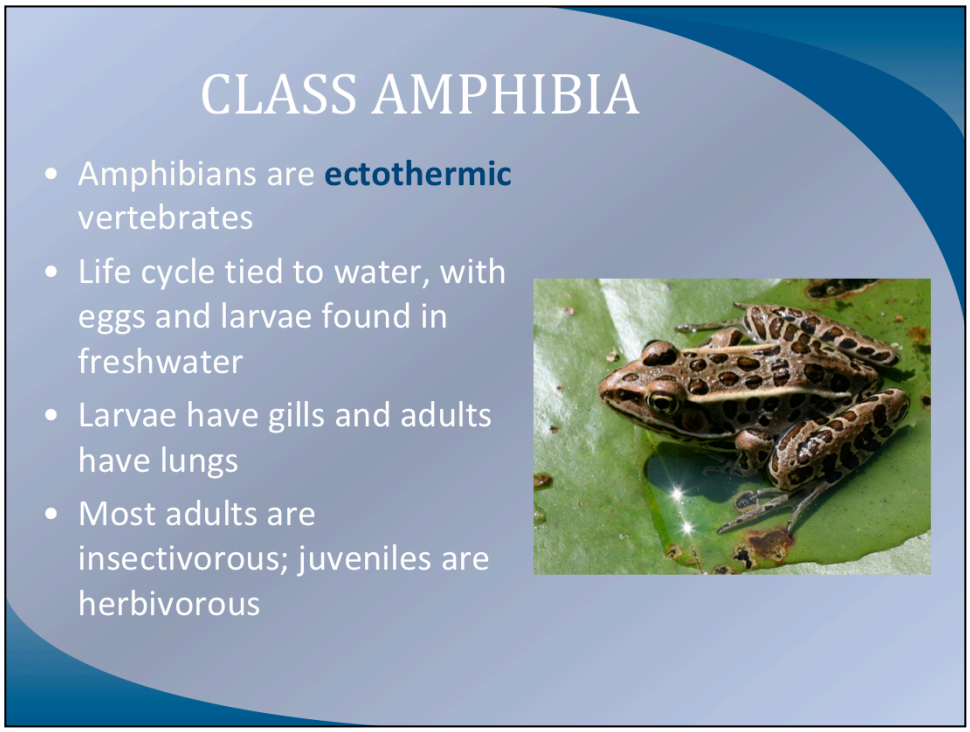
Emerging from the water out onto land presented disadvantages to the amphibians. Their gas-permeable skin, which serves to aid their inefficient lungs, requires moisture and their jelly like eggs cannot survive out of water.

There are three Orders of amphibians: the frogs and toads, the salamanders and newts and lastly the caecilians.



Vertebrates are the most advanced organisms on Earth; they are animals with an internal backbone or spinal column. This **endoskeleton** can grow with the organism unlike the exoskeleton of arthropods, which requires regular molting. An endoskeleton provides greater flexibility in movement and will support greater weight without becoming too heavy for the organism. Vertebrates have a well developed head with an encased nervous system, including a brain and nerve chord encased in a backbone. With a highly developed nervous system, vertebrates can react very quickly to changes in their surroundings, giving them a competitive edge. They also have a muscular system and a skeleton that supports and protects their internal organs and provides mobility. Vertebrates are often larger and have more complex bodies than invertebrates.

The vertebrates include fish, amphibians, reptiles, birds, and mammals.



The word amphibian comes from the Greek *amphi* and *bios*, meaning "double life", that is, they can live or function on land and in freshwater. Amphibians are **ectothermic** animals; they are unable to regulate their own body temperature and depend on external sources. Despite their adaptations to terrestrial life, amphibians require cool, moist environments for their eggs and their skin. Amphibians are mainly temperate and tropical species. Most adult amphibians are **insectivorous**, though many of them eat plants at some point in their lives.

Amphibians are capable of breathing in four different ways. Amphibian larvae have gills. In the adult stage, most amphibians (especially frogs) lose their gills and develop lungs. Lungs serve dual purposes in most amphibians. They function in breathing and help in control of buoyancy. By changing the amount of air in their lungs, amphibians increase their ability to sink or to float. Amphibians can breathe through their skin; they have naked skin; it lacks fur, feathers, or scales. Lastly, the throat pulsation of amphibians is a type of breathing called **buccopharyngeal respiration**.

Adults have a three-chambered heart. In the juvenile (or tadpole) stage, the circulation is similar to that of a fish; the two-chambered heart pumps the blood through the gills where it is oxygenated, around the body and back to the heart in a single loop. The three chambered heart is more efficient in delivering oxygen to the organs and tissues of the body than the two-chambered.

Amphibian have mucous-producing glands in an amphibian's skin, which moistens the skin, optimizing oxygen absorption and protection from drying out. Many species absorb oxygen through their skin, absorbing it directly into the blood vessels. Carbon dioxide is also released out through the skin. The absorption process is more efficient when the skin is moist all of the time. Amphibians do not drink water; they absorb and release water through the skin and can even absorb water from moist soil.

The skin of amphibians also protects against abrasions and parasites; the skin has substances that protect the species from some microbes and viruses, offering possible medical cures for a variety of human diseases, including AIDS.

Because of their permeable skin, amphibians are considered an **indicator species** as to the health of the environment; they are vulnerable to environmental disturbances, from chemical pollution to the thinning ozone layer and global climate change. Amphibian species are an advanced warning of some danger, like “a canary in a coal mine”.

Amphibians have good sight to locate prey. The life cycle of many amphibians requires them to see underwater and on land. Amphibians focus their eyes by a change of position of the lens, rather than by a change in the shape of the lens in reptiles, birds, and mammals. Amphibians that have gone through metamorphosis, larval salamanders, and a few tadpoles, rely on their sense of vision when finding prey. The movement of prey is necessary to trigger the feeding response. They have a **nictitating membrane**, which allows them to protect their eyes without obstructing their vision.

Their sense of smell is well developed in most amphibians, but it is best-developed in burrowing toads, newts, certain salamanders, and caecilians. Newts and salamanders use it to smell **pheromones** of their species during breeding season. These chemical scents are important in courtship, for finding and recognizing mates, in egg-clutch recognition, and in the detection of territorial boundaries.

Toads and frogs are very vocal animals. They were the first animals to develop true vocal chords. Males have a distinct mating call to attract females. Frog calls or croaks are species specific and usually only the males call to attract mates. Sometimes the mating call must carry over a large distance, so they can be very loud. Salamanders, newts, caecilians, and amphibian larvae have no vocal abilities and therefore are assumed not to hear very well. Toads and frogs have well developed ears, and hearing is used to recognize different species vocal signals. These signals are used to establish territories and in attracting mates.

Most amphibians will eat almost any live food that they can manage to swallow. Insects, spiders, snails, slugs and earthworms form the main part of the diet for most adult amphibians. Larger species, like the smoky jungle frog, will take larger prey, e.g., a mouse. All amphibians will gorge themselves if food is plentiful to enable them to survive when food is scarce.

Frogs are more active feeders than toads and will not often sit and wait for their prey. Frogs tend to go after fast-moving insects, like flies, crickets, and grasshoppers. Toads tend to eat slow-moving insects, like wriggling mealworms or earthworms. Their sticky tongues are able to quickly pick up the prey.

Newts, salamanders, and caecilians tend to eat slow-moving, soft-bodied animals, like earthworms. They approach their prey slowly, then make a quick, last minute grab, often turning their head to one side. They grip the food using teeth in their upper and lower jaw.

Cool Fact: Have you ever noticed that amphibians blink when they swallow food? The blinking of the eye pushes the eyeball down into the skull, and helps the amphibian swallow its meal!

Each year predators eat millions of amphibians. Amphibians employ a variety of tactics to ward off predators. An amphibian's main defense mechanisms are camouflage and brightly colored skin that acts as a warning to predators, showing that the species is poisonous. Many can also excrete toxins through the skin to discourage predation. An amphibian's poison defense is usually a last resort and will only work if a predator tries to eat it.

Many newts and salamanders use mimicry to defend themselves. The non-poisonous, yellow-eyed salamander is a mimic of the highly poisonous California newt. It resembles the newt in dorsal coloration and has the newt's yellow eye color.

The colorful fire-bellied toad usually relies on their excellent camouflage to stay hidden from predators. If the toad is cornered and there is no chance to escape, the toad goes into a defensive posture - arching its back and showing the bright warning colors of its underside.

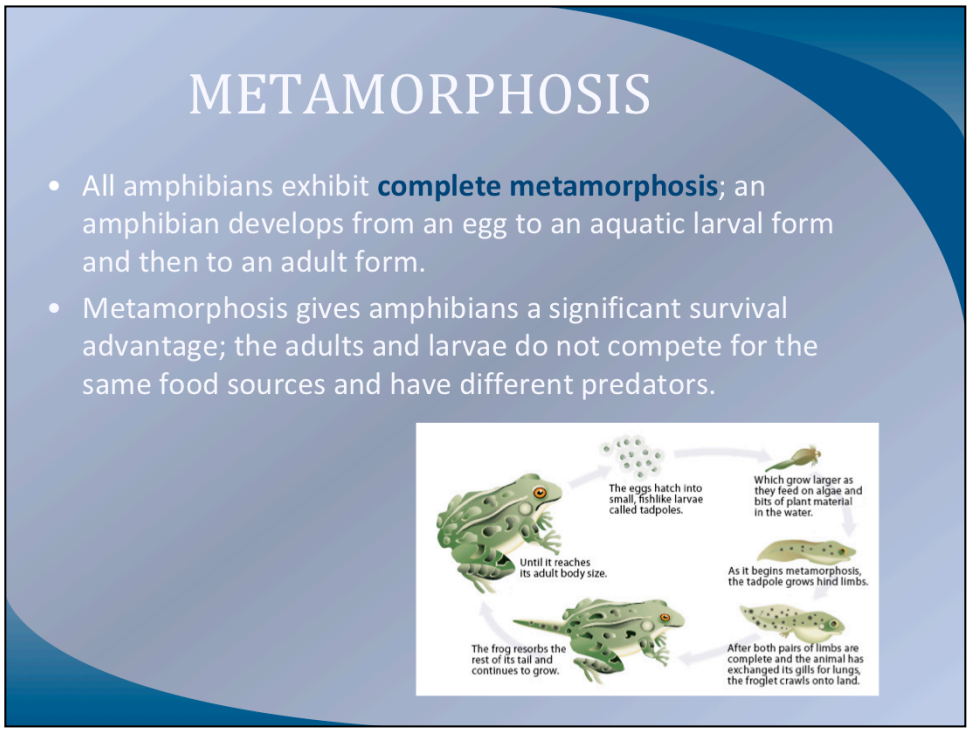
True toads, like marine toads, have an enlarged paratoid, or poison gland behind each eye. If a toad is threatened by a predator, a poisonous, milky secretion oozes from the gland's pores. If the predator gets the poison in its eyes or mouth, it suffers a burning sensation and muscle spasms, causing irregular heartbeats and breathing difficulties.

The poison dart frogs eat insects who ate toxic plants and therefore become toxic themselves. Note: the poison dart frogs at the zoo do not have the toxins in their skin because they are eating different nontoxic foods.

The amphibian egg is similar to the fish egg. The egg is composed of a series of jellylike layers that protect the developing embryo from desiccation, pathogens and, to a limited extent, predators. Oxygen and carbon dioxide diffuse passively through the outer membrane, enabling the developing embryo to breathe. Because of the lack of an outer shell, the egg must be deposited in the water or a very damp location to prevent drying out. A few species will lay eggs on land in wet soil or plants or retain the eggs in their bodies, thereby negating the need for water.

Not all amphibians lay large numbers of eggs in water and then leave them to hatch as free-swimming tadpoles. Many amphibians are attentive parents. The amount of parental care an amphibian gives is related to the number and size of eggs produced. Fewer, larger eggs receive more care; many small eggs receive less care. The kind of care ranges from choosing a sheltered egg-laying site to enclosing the eggs in protective foam, to actually guarding the eggs. Some amphibians carry their eggs or tadpoles on their backs in thin pockets (i.e Surinam toad); others take their eggs inside the body, into a vocal sac or even into the stomach. Two species of caecilians give birth to live young.

Fertilization is external in the frogs and toads. The male usually grasps onto the back of the female to fertilize the eggs as they are deposited (**amplexus**). Salamanders and newts males deposit a sperm packet, which is taken up by female for internal fertilization. Caecilians also exhibit internal fertilization.



Amphibians are the only four-limbed or land vertebrate that go through a **complete metamorphosis**; they change from the aquatic larval form, or tadpole into an adult form.

During metamorphosis, tadpoles lose their gills and develop lungs. Metamorphosis is important in amphibians because the adults fill a different niche then the larvae and so do not compete with them, giving them a better chance of survival.

Although full metamorphosis averages 12-16 weeks, this time span is greatly affected by water temperature and food supply.

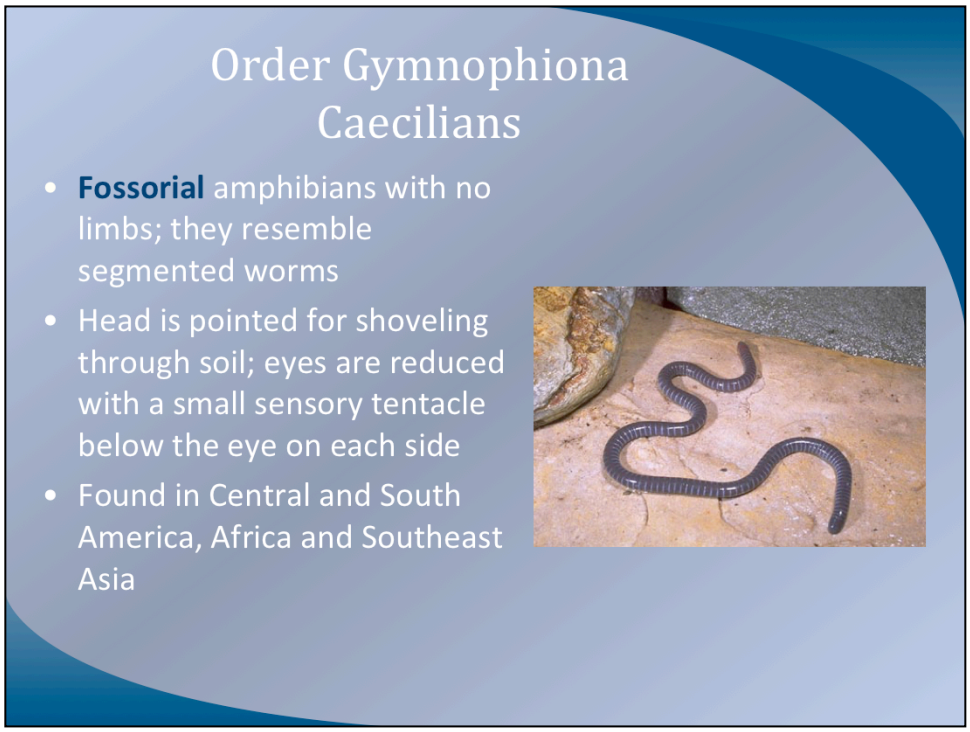
As adults, salamanders are generally more terrestrial, and newts are more aquatic. They both maintain a tail into adulthood. This Order is the only one that has some adult species that remain aquatic and retain gills. For example, the mudpuppy retains its gills and remains aquatic throughout its life. Salamanders typically have longer and more rounded tails with well-developed toes for digging in soil. Most newts have webbed feet and a paddle-like tail, which make it easier to live in the water. Species are mainly from the Northern Hemisphere and all are **insectivorous.**

Newts metamorphose through three distinct developmental life stages: aquatic larva, terrestrial juvenile (called an **eft**), and adult. At the eft stage of metamorphosis, the North American newts will they leave the water and live a terrestrial life. Once the eft reaches adulthood this species returns to live in water, rarely venturing back onto the land.

Some **salamanders** have bright colors to warn of toxic secretions, while others use them to attract mates. Some salamander species can shed their tails if attacked. Later, the tail can grow back. Salamanders have a largely cartilaginous skeleton, while that of frogs is more rigid and bony to withstand the impact of jumping and landing.

In most newts and salamanders, courtship and mating involves a behavior display by the male for the female. The male has to find a mate of the same species and guide the female over a small sperm packet (spermatophore), which he deposits on the ground or in a pond. Fertilization is internal as the female picks up the sperm packet with her cloaca. Despite internal fertilization, these amphibians must return to the water each year to breed.

In primitive salamanders, like the hellbender (the largest aquatic salamander), the female lays her eggs first and then the male deposits his sperm over them. The Sculpture Learning Plaza has a hellbender.



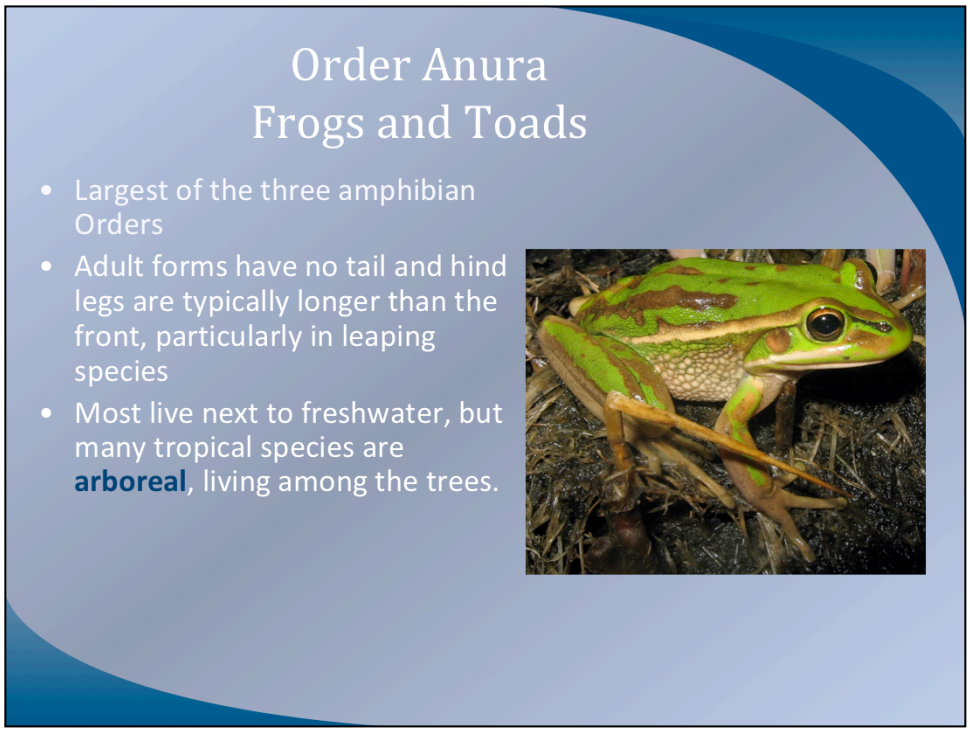
When amphibians were the first creatures on land, there were no snakes. There was an entire ecological niche to be filled. Some amphibians evolved to slither along the ground and eat insects and worms. Those slithering amphibians got into tight spaces and filled a specialized ecological niche that snakes filled millions of years later. These are the caecilians. They are found in Central and South America, Africa and Southeast Asia.

The caecilians resemble large segmented earthworms. They are long-bodied, limbless amphibians with virtually no tails. They are rarely seen by humans due to their almost entirely **fossorial** (burrowing) lifestyle. Some species are entirely aquatic and have a fin on the tail.

A caecilian head is pointed for shoveling through soil and they have reduced eyes with a small sensory tentacle below the eye on each side. Caecilians have dense, rigid skulls for burrowing through hard sediments, but they have lost all components of the appendicular skeleton.

Caecilians have a special kind of internal fertilization in which the male inserts the end of his cloaca into the female's cloaca.

The Sculpture Learning Plaza has a caecilian.



Anura is the largest of the three Orders and includes the frogs and toads. Anura means without a tail and an absence of a tail is a distinctive characteristic of this group. Tadpoles have a tail for swimming but the adult forms have no tail. Their hind legs are typically longer than the front, particularly in leaping species. Most live next to freshwater streams and ponds, but many tropical species are adapted to an entirely arboreal life, including tadpoles swimming in plants that hold water such as the bromeliads.

Frogs tend to be more active than toads, are found in or near water, have smooth moist skin, long hind legs, and fully webbed feet. Toads tend to be less active, prefer to live on land, have dry, warty skin, short legs, and little or no webbing on their feet.

Many frog and toad species are highly toxic. The parotid glands behind the eyes in many temperate species such as bullfrogs and marine toads secrete powerful poisons when bothered. Other tropical species such as poison dart frogs exude toxins from their skin and have bright warning coloration. Poison dart frogs obtained the toxins from insects they eat, who got the toxins from plants they ate.

Many species have developed camouflage and look like leaves or are even transparent, so they look like their background.

The Tropical Building has a variety of amphibians including some poison dart frogs, smoky jungle frogs and red-eyed tree frogs. The Sculpture Learning Plaza has a horned marsupial frog and a goliath frog.

Amphibians are still being discovered at the rate of 15-25 new species a year. However, 1/3 of the world's amphibians are considered threatened. To illustrate the growing crisis, 2008 was designated the Year of the Frog. Amphibians play a crucial role in the food web, especially as predators and as prey for other animals. The los of amphibians would result in disastrous ecosystem-wide effects in terrestrial and aquatic environments.

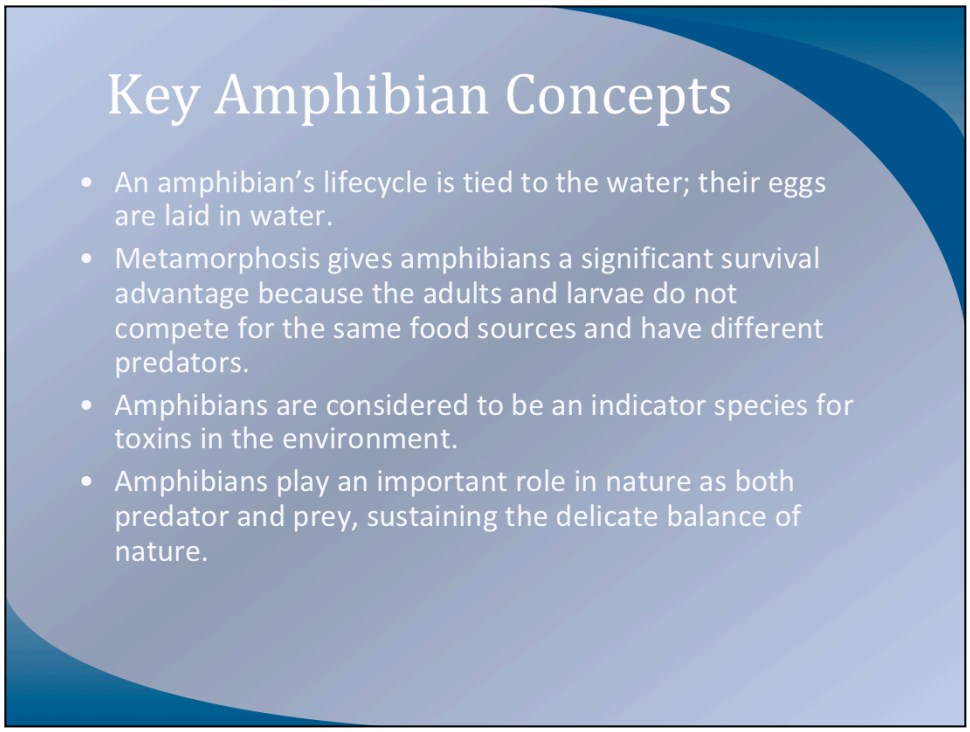
Since amphibians have moist skin that helps them breathe, they are very vulnerable to poisons. Defects and mutations such as multiple or deformed legs appear in affected populations. Pesticide runoff from farms as well as pharmaceuticals flushed down the toilet have contributed this issue.

Chytridiomycosis (or **chytrid fungus**) is a fatal disease caused by a fungus that is affecting amphibian populations worldwide. Chytrid is responsible for the major decline or extinction of many species.

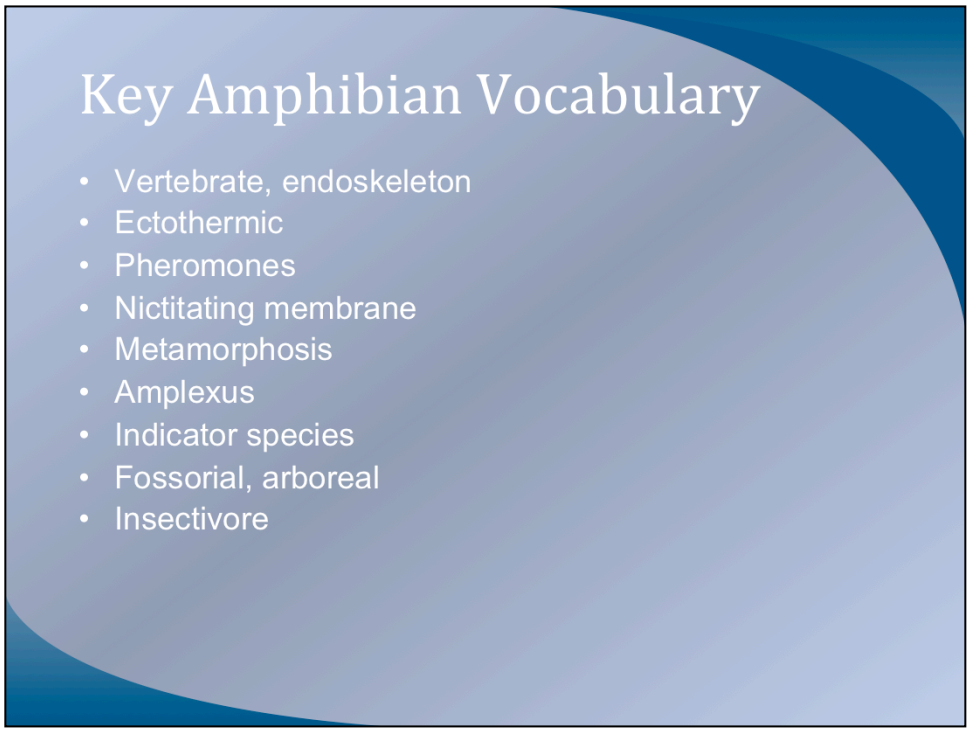
Introduced species can out compete native species to the point of extinction. An example of this is the marine toad was introduced to Australia from Hawaii. A prolific breeder, the marine toad steadily increased its range.

Previously, mountain yellow-legged frogs were expunged from Tahoe lakes by introduced non-native fish, which eat their eggs. SF Zoo partnered with the US Forest Service, California Department of Fish and Wildlife, wildlife researchers, and others to to breed inoculated frogs. These frogs were successfully reintroduction in 2014.

Another joint project involved the Zoo and the National Park Service at Yosemite National Park to reintroduce California red-legged frogs, Yosemite toads as well as the western pond turtles to Yosemite Valley with the goal to establish self-sustaining breeding populations in Yosemite Valley by 2020.



Corresponds to the Amphibia Study Guide in the Docent Notebook. For specifics on the Zoo's amphibian collection read the Amphibia Fact Sheets in the Docent Notebook and go to the SF Zoo's website (sfzoo.org)



Definition:

Amplexus: the mating embrace of a frog or toad during which eggs are shed into the water and there fertilized.

Arboreal: living in the trees.

Buccopharyngeal respiration: a type of breathing in amphibians; the throat pulsation of amphibians brings air over the respiratory surface on the lining of their mouth where gas exchange takes place readily.

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

Endoskeleton: an internal skeleton, such as the bony or cartilaginous skeleton of vertebrates.

Fossorial: an organism that is adapted to digging and life underground.

Indicator species: a species whose presence, absence, or relative well-being in a given environment is indicative of the health of its ecosystem as a whole.

Insectivore: an animal that eats only or mainly insects. An insectivore is a carnivore.

Metamorphosis: a major change in the form or structure of some animals or insects that happens as the animal or insect becomes an adult.

Nictitating membrane: is a transparent or translucent third eyelid present in some animals that can be drawn across the eye for protection and to moisten it while maintaining visibility.

Pheromones: a chemical substance released by an animal that serves to influence the physiology or behavior of other members of the same species.

Vertebrate: an animal with an encased nervous system including a well-developed brain and a nerve chord that runs through the spinal column or backbone.